MAIN CURRENTS

IN MODERN THOUGHT

Freedom to act intelligently and wisely involves many factors, not the least of which is a knowledge of the natural laws which are progressively revealed by science, it being evident that freedom is consonant with order and not with chaos. That our crises are of a conceptual nature, deriving in part at least from the lack of a sound and shared philosophy, is now becoming more and more generally recognized. Since concepts shape culture, the validating intellectual techniques of modern exact science and particularly hypothetical-deductive science, provide a primary solid basis from which to approach with new hope the distinctly human and social problems.

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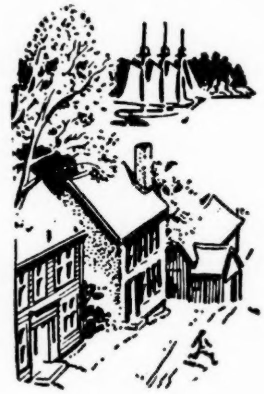
MAIN CURRENTS IN MODERN THOUGHT

A co-operative journal to promote the free association of those working toward the integration of all knowledge through the study of the whole of things, Nature, Man, and Society, assuming the universe to be one, dependable, intelligible, harmonious.



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"Ah, but a man's reach should exceed his grasp, or what's a heaven for?" — BROWNING

Editor: F. L. KUNZ Associate Editor: E. B. SELLON

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AIMS OF THE FOUNDATION FOR INTEGRATED EDUCATION

The Foundation is incorporated under the laws of the State of New York as a non-profit educational organization. Contributions are tax deductible.

The corporate statement of Aims declares that the Foundation has been established:

1. To collect, create, and distribute authoritative materials which will encourage the development of unified overall concepts in education; to improve the balance of relationships between the physical sciences and the social sciences; to inquire into the phenomena of purposive activity in nature, man and the universe.

2. To assist teachers to understand and use such materials, and to develop an active, realistic, comprehensive philosophy which will communicate to their students the unity, coherence, and beauty of the world in which we live.

3. To remedy, solely by such educative measures, the conceptual and hence the ethical, social, economic, and political breakdown of our times, looking to a peaceful world order.

The members, associates, and staff of the Foundation realize that the progressive discovery of unifying over-all concepts concerning man and the universe is not a task to be performed successfully in isolation from the historical, social, economic, and political context of our times, nor in terms of application less than global.

The work of the Foundation is wholly educational, yet referred constantly to the contemporary scene in all its aspects, no less than to the total available wealth of human experience and knowledge.

MAIN CURRENTS IN MODERN THOUGHT is published quarterly to call attention to significant contributions to learning currently being made by leading workers in the multiple fields into which knowledge has come to be classified. It relates these advances to each other and to the classical and contemporary views of Eastern, European and American thinkers. It is designed to save time for the reader by providing a vantage-ground from which the whole world of knowledge may be surveyed and kept in proportion as it moves toward integration. Its editors assume that the principles of art, the universals of philosophy, the laws of Nature and Man as formulated by science, and the truths of comparative religion, can be orchestrated into a harmonic, meaningful, ethical body of teachings which can and should be made the central core of curricular study in the educative process at all levels of development. In condensing text, square brackets [ ] indicate editorial interpolation. Three dots . . . in the text indicates a word, phrase or passage omitted in the interest of brevity or clarity. Other usages are standard. $3.00 a year. Foreign $3.50. Contributors to MAIN CURRENTS enjoy full liberty of opinion and expression in these pages. *to whom all communications regarding MAIN CURRENTS IN MODERN THOUGHT should be addressed. Entered as second class matter April 13th, 1946, at the post office at Port Chester, New York, under the Act of March 3rd, 1879.*

THE FOUNDATION FOR INTEGRATED EDUCATION

NEWS AND NOTES

The six-day workshop at the University of New Hampshire (August 23-29) provided an opportunity for participants from 33 colleges and universities to discuss the problems inherent in the course in Integrative Concepts in Science, Philosophy, and Education, which will be conducted jointly by the Foundation for Integrated Education and New York University throughout the coming school year. The workshop had its origin in a suggestion made by Professor Mark A. May (Yale University) at the January 20 meeting of the Foundation with a group of teachers (reported in MAIN CURRENTS, Vol. 8, No. 2).

A grant for the conference was made through the Humanities Division of the Rockefeller Foundation to ensure the attendance of lecturers of the course. The opportunity to discuss integrative concepts attracted others in educational or allied fields, bringing the total number of persons attending the sesssions up to 109, including families. The hospitality of President Robert Flint Chandler, Jr. and faculty members of the University of New Hampshire was cordial, and its expression through Henry Bailey Stevens, Director of University Extension, gave a feeling of home-coming to those who had attended the first workshop of the Foundation at Durham in 1948.

Professor Henry Margenau, as chairman of the course and the workshop, gave energetic, patient, and skillful leadership. In his introductory remarks he asked the lecturers present to review briefly the principles and sequence which each proposes to pursue in his contribution to the series. Members of the course advisory and management groups were also called upon to raise issues; and impromptu auxiliary aid was sought from various scholars. The conference, in short, was a workshop in the most practical sense of the word, and those responsible for the course are greatly indebted to participants for their counsel.

The course itself is offered through the Division of General Education and is recognized for graduate credit in the Department of Education at New York University. It will provide representative concepts which seem to promise usefulness as deep-lying elements of unity bringing together the sciences and the humanities. In order to reduce the operation to something like manageable proportions in the first term, special notice is to be taken of the deductive-exact elements in older and newer physics, astronomy, and geology, and in the several major aspects of biology. (The offerings in the second term include psychology, sociology, general philosophy, and education in the main. Discussion of this portion of the study will be taken up in a succeeding issue of MAIN CURRENTS.) The natural sciences contain varying emphasis upon correlational-statistical, and upon deductive-exact methods. Hence, lectures on physics naturally involve much of the latter, and lectures on other topics necessarily less, as a rule. In order to maintain in the students a lively awareness of the deductive elements, time in the so-called summary lectures in the first term will be alloted to reviewing the methods, concepts, and content which contribute to a better understanding of the laws of nature implicit in deductive systems.

In the main workshop activity—synoptic rendering of course lectures—it was not thought necessary to adhere to the lecture sequence of the course itself. Accordingly, the process of summarizing and discussing each lecture began the first morning with digests of the first, second, and eighth lectures by the undersigned, Professor Margenau, and Professor William Seifriz (University of Pennsylvania). Each of these digests was followed by close discussion and the writing on the blackboard of the points made. (A summary of the first lecture, "Motivation and Need for the Course," will be found on page 73 of this issue of MAIN CURRENTS.)

Professor Margenau summarized the second and third lectures in the course ("Mechanism and Space-Time" and "The Breakdown of Mechanism, the World of Quanta"). He discussed the following principles:

1. Science has now accepted *action at a distance* rather generally in favor of contact forces. This makes possible the application of physical methods (the field concept) to a considerable variety of other disciplines.

2. Even in ordinary mechanics (and more so in quantum mechanics) *the whole is more than the sum of its parts.*

3. The *controversy between vitalism and mechanism* has ceased to be meaningful because physical science no longer regards the Rube-Goldberg type of mechanics as adequate.

Professor Seifriz gave an exhilarating talk on protoplasm, showing his wisdom, humor, and obvious command of both empirical and deductive scientific methods in the crucial field of biology. His synopsis brought together the chemical and dynamic nature of the fundamental material

of living organisms. On one evening he also showed most extraordinary motion pictures of living protoplasm.

Professor Ashley Montagu (Rutgers University) discussed the shortcomings of the classical Darwinian concept of survival of the fittest and presented a lucid thesis in which cooperation as a factor in the life of all organisms is at least as important as competition.

Professor May examined theories of learning from the point of view of the chief schools of psychology. In so doing he pointed out that living organisms can by their own behavior change conditions that define future behavior.

The significance of the Foundation's chosen method and process of integration for the training of teachers was examined by Professor George Axtelle (New York University) and Professor Theodore Brameld (New York University) in an informal discussion in lieu of lecture summaries. Agreement was nearly unanimous that the generalizations which must necessarily guide the training of teachers, for secondary and higher levels particularly, can and must be given specific form and substantial content by drawing heavily upon the conceptualized structure of the sciences, as the course is intended to do. The high place of the arts and indeed every aspect of the humanities was, naturally, conceded without question, but the necessity to introduce the cultural meaning of the sciences into the circulatory system of educational training was emphasized.

The summary of the lecture on symmetry and living nature, which is to be contributed by the undersigned, had to be limited chiefly to identifying the formal mathematical background. The synopsis necessarily emphasized the theoretical element, and suggested incidentally empirical, historical, and philosophical implications.

Professor Harlow Shapley (Harvard University) illustrated his discussion of the nature and behavior of stars with motion pictures of time lapse photography of explosions on the sun and slides of typical celestial objects, touching upon modern concepts of the birth and evolution of stars, the distribution of galactic systems, and the expanding universe. The speaker's resources of knowledge, judgment, and humor, exercised during a long discussion period after the lecture, were enjoyed by all.

The whole workshop enterprise was thrust home the final evening when Professor F. S. C. Northrop (Yale University) examined the relation of simpler concepts by intuition to structural concepts by postulation, throwing vivid light of method upon the discussion of content. He also contributed much to the final morning's review and summing-up of the whole fruitful period. So also did Professor George A. Lundberg (University of Washington) who found it possible to attend several sessions, and to offer us most competent advice.

A special meeting on the last day of the workshop was devoted to the mechanics of running the course, the directives being put forth chiefly by the audience. The following points were made:

1. It was felt that all lectures should contain factual material *plus* a discussion of methodology. Some lectures are heavy with content alone; they are most interesting and will, no doubt, be enjoyed by the students. From an educational point of view, however, it seems desirable that a discussion of method, in the basic philosophical sense, be added where this is possible.

2. Throughout the course there should be stress on integrative ideas, on fundamental principles which form vistas leading from one discipline to another. (An example of this stress, as brought out in the workshop, is the above listing of three key issues by Professor Margenau in his summary of the second and third lectures.)

3. The educators present at the workshop felt keenly that there should be more continuity between the lectures than chance could be relied upon to produce. This poses a difficult problem for the chairman. The suggestion here made was merely that participants in the course endeavor, so far as time permits and as seems reasonable, to familiarize themselves with the contents of preceding and succeeding lectures. The source book which will be in their hands can serve as a vehicle for continuity.

4. The meetings ended with one very specific proposal which the chairman has accepted. It is that Professor Margenau should use the sixth lecture of the first term, now called "Summary," to present the elements of his methodology of physical science. It was felt that this provided a measure of unification and a tie-up between the preceding lectures. In the last lecture of the first term, Professor Northrop would then take up the same train of thought and generalize it by applications to a wider field. This last suggestion need have very little effect upon the contents of other lectures because the framework of Margenau's discussion (in term of sense data, theoretical constructs, and epistemic correlations or rules of correspondence) is wide enough to accommodate their substance.

Besides the summaries made by the course lecturers, many other participants in the workshop contributed in informal talks and discussions to the integrating of the course. Professor Lester Dix (Brooklyn College) described the usefulness of the broad idea of design in nature as a basic concept uniting the arts and the sciences. Professor John A. Timm (Simmons College) devoted both scheduled and incidental hours to explaining new developments on the frontiers of physics and chemistry. Another hour was devoted to discussion of administrative problems posed by the project. Here Professor Sidney Roth and Professor William Gruen, both of New

York University Division of General Education, guided the discussion.

A variety of participants generously contributed auxiliary discourses. Professor Robert Hartman (Ohio State University) described a research project in the theory of values which has been approved by the Foundation Council to be pursued under his direction. His remarks were so provocative as to require a continuation. Professor Morris Mitchell (Putney Graduate School of Teacher Education) gave an interesting account of a specific educational and economic development in the TVA area, and aimed his argument for educational co-operation up to the very level of the United Nations and Unesco. Professor Herbert W. Schneider (Columbia University) presented a tabulation which carries the concept of field right across the board of departmentalized knowledge.

Another special assignment of time was made to consider the Source Book in Supplementary Reading prepared for the course. This is (at present) a volume of 226 closely typed mimeographed pages for the first term lectures alone. It is not a text, but consists — except for the Preface and Chapter 1, which appear elsewhere in this issue of MAIN CURRENTS — of quotations which will supplement each lecturer's discussion, introduced in most cases by a summary. In addition, a bibliography accompanies each chapter in support of each lecture. The Source Book is the work of Mr. Robert P. Whorf (West Virginia University) and his wife, Margaret Whorf. Its readying was possible only because of the intense effort which they were prepared to give it after a special private grant finally made it possible to start work. As time, resources, and manpower permit, the first volume will be enriched by a glossary, some tabulations, and further introductory and illustrative material, but as it stands, it was unanimously praised as an invaluable contribution to the course.

The workshop was by no means limited to abstract intellectual exercises and discussion of administrative and pedagogical problems. Besides the motion pictures of protoplasm shown by Professor Seifriz and those of explosions on the sun shown by Professor Shapley, Professor Marie Clark Taylor (Howard University) very gracefully accepted an impromptu assignment to interpret some time-lapse motion pictures in color of the growth of plants under constant light source. It was agreed that these and other good visual aids should be employed wherever possible in the course itself. On still another evening, the late Robert Flaherty's last full-length motion picture, *Louisiana Story,* was shown through the courtesy of Flaherty Associates. The six days of close discussion were further diversified with outings to nearby points of interest and excursions to the beach. The general willingness to give late and odd hours made it possible to hear unscheduled offerings (such as those by Dr. Robert Drews and Dr. Helen Hall Jennings) without invading the free time unduly.

In the course of the workshop, major and persistent problems in connection with integration of knowledge came to the front, as was to be expected. That the sciences rich in postulational and theoretical structure are those of matter and energy is well known. Previously this has led to a dilemma: reduction of other subjects to sciences of the insentient, or the reexamination of biology, psychology, and sociology with a view to applying and enlarging in them the basic principles and methods which are employed in physics and chemistry, but now on terms suitable to the essential subject matter, preserving and understanding sentience, purpose, and the like. Today on the very frontier of physics, new conceptual developments are available which promise to make it possible to dismiss the dilemma, but they have to be stated. Among other things, the course promises to offer an interesting commentary by numerous experts on the question of the applicability of physical reasoning to the non-physical world.

A sharp turning point in the discussion concerned the problem of extending essential terminology from narrow and exact applications to larger areas. The case of field theory in physics and the use of the term "field" in biology, in psychology, and in sociology was brought forward. The question was discussed as to whether or not the conceptual contents are the same in each case.

Still another basic discussion concerned the sense in which the term "integration" is to be understood in connection with the workshop, the course, and the fundamental activities of the Foundation. On this head, some pertinent remarks as respects the course will be found on page 71 in the Preface to the *Source Book.*

The problem of the course will be to state the very considerable number of concepts which may originate, or be most useful and precise, in some given discipline, but may have significance in many. Terms and phrases such as symmetry, or fields, or entropy-and-order refer to such items. These concepts must be stated in unambiguous and non-technical form. But — as

the workshop made clear — the integration of knowledge is not merely an intellectual enterprise. The beauties of living come from a union of profound thought, and generous, aesthetic, and affective emotions. Hence the conceptual materials are best communicated from person to person. An important aspect of the conferences of the Foundation has invariably been the sense of adventure and of common cause felt by all preent. There are numbers of educators who are eager to possess and use the structural elements now developing on the frontier of knowledge, and they are obliged to acquire some of the more technical of these in an immediate, living, give-and-take atmosphere.

Whereas the 1950 Stillwater Conference sharply focussed methodological findings, the 1951 Durham Workshop made clear that work upon the toughest problems of our times becomes fun when treated in terms not narrowly intellectual. The world's problems root in ignorance, but men's darkness is in their faulty emotions as much as in their irrational processes. An atmosphere of patient, friendly, and hopeful concentration upon the intellectual problem was clearly experienced as contributing to final solution. The helpful counsel given for the success of the course received most effective force through this display of resolute common cause in an urgent, difficult, and complex task.

F. L. KUNZ

PERSONNEL ACQUISITIONS

The growing body of the Foundation for Integrated Education has been strengthened by the addition to the Council of an experienced and resolute advocate of general and integrative education, Dean Schiller Scroggs, Oklahoma Agricultural and Mechanical College. Dean Scroggs attended the Montecito Workshop, 1949. He was instrumental in putting together the Foundation's invaluable Stillwater Conference, 1950, and provided us with a printed volume of proceedings, *The Nature of Concepts, Their Interrelation and Role in Social Structure.* He is chairman of the Committee on General Education of the Department of Higher Education in the National Education Association, and edits the bulletin thereof. It would not be easy to find a more mature mind for the work in hand, or someone more conversant with the bearing of the program of the Foundation upon world issues.

The staff of the Foundation has been enlarged, and most effectively vitalized, by the acceptance of the post of administrative officer by Mr. Harvey W. Culp, until recently executive dean of Briarcliff Junior College. Mr. Culp's educational background in sciences, engineering, literature, and psychology, acquired at Massachusetts Institute of Technology and Columbia University in the main, are significant, and his executive experience invaluable, for the work in hand. Among other direct participations in the development of the thought of our time, he assisted the late Alfred Korzybski in the writing of *Science and Sanity.* Mr. Culp has acquired a large circle of friends in the world of education. The Council, Directors, and staff of the Foundation are happy to have enlisted the help of so keen and adventurous a mind and an administrator so public-spirited and experienced.

ANNOUNCEMENT

The Source Book of Supplementary Readings for "The Frontier of Knowledge: Integrative Concepts in Science, Philosophy, and Education" (First Semester, 1951) is ready in mimeographed form for students. The Foundation has received many inquiries as to its availability more generally.

The Source Book is a work in progress in which continuing cooperation of all users of the volume is solicited. Hence the limited supply that has been prepared in response to these requests is intended specifically for colleges and individuals cooperating with the Foundation's program. The price is $3.00 per copy plus 50c for postage. Please send remittance for the total amount with the order and indicate the faculty position and function of the purchaser.

INTEGRATIVE CONCEPTS IN SCIENCE, PHILOSOPHY, EDUCATION

The following two papers constitute the Preface and Chapter 1 of the Source Book in Supplementary Readings for the course, "The Frontier of Knowledge: Integrative Concepts in Science, Philosophy, and Education," to be given at New York University during the current school year.

PREFACE

Our times have presented the educator with a paradox that is probably unique: society, in order to expand its benefits to larger numbers of men, requires specialization of skills and of knowledge; yet this same specialization threatens to destroy society. The threat takes many forms, some political, some moral, some scientific. It reaches even the specialist himself when he is in quest of knowledge concerning fields other than his own, for he has ceased to speak the language of the other specialists. Thus the researcher, in many instances, has turned provincial and, worse, has come to feel very much alone.

Yet specialization must not be regarded as an evil, because the welfare of our society rests on it. We cannot turn back the clock. Our goal must be to enlarge the process of education, to widen its scope as well as increase the number of its beneficiaries. For every specialist we must produce several men with a wholesome respect for the specialist's work, but able to see its relation to the larger problems of our existence, and we must reform the specialist to look upon such men as equals. Many see this challenge coupled with another: the need to rescue our masses from the doldrums of their idleness, which has become debasing and degenerating because of our moronic forms of popular entertainment.

Obviously, we must integrate our knowledge, our culture, our education. But the problem, easily obscured by the ready availability of so satisfying a word as integration, is how to achieve it. Our ills are specific; the cure implied is often very vague. We need, first of all, a careful examination of the meaning of "integration."

The oldest, and in a sense also the newest, meaning is *conversion to a dogma.* The conversion may be persuasive or enforced; it generates a kind of regimented uniformity which can act as a most effective integrator. But history shows this form of integration to be sterile, and it is out of harmony with other vital precepts of our culture.

Another way to integrate knowledge is to *collect known facts,* to appraise their trustworthiness and to tabulate them for reference. This ideal of the Encyclopedists and some modern pragmatic philosophers is indeed worthy of being pursued, and it actually enjoys a great deal of current attention. But whether the key to integration may not lie among the facts as yet unknown, and will therefore remain missing when the known facts are assembled, is a gnawing doubt which takes the zeal out of this useful effort.

More fundamental than collecting facts seems to be the kind of integration arising from an *analysis of the language* which carries and transmits accurate information. Semantics is an integrator of considerable potency, for it draws attention to the medium in which bare facts are imbedded, a medium which in part fashions them and gives them their significance in discourse.

But knowledge, attitude and culture have roots that go below facts and go below language. To be impressed with this plain truth means to advocate a fourth kind of integration. The facts of our knowledge, the visible excrescences of our culture are in a sense less important than the roots from which they spring. Lack of continuity and organization between facts, gaps between disciplines of learning, failure of understanding between people and peoples can be viewed as signs indicating places where conceptual roots, though present in the deeper soil, have for some reason not pushed up to the surface. Discontinuities are in many instances confined to the surface, and a probing for basic concepts may eliminate the discontinuities. For it is the nature of concepts to be extensible, while facts can only fill dead spaces in knowledge. Concepts guide the researcher when he is looking for facts, and therefore *the present endeavor seeks integration in the realm of fundamental concepts.* It thereby allies itself to other worthwhile movements presently on foot, but it places its emphasis where it has hitherto seemed to be lacking.

The Foundation for Integrated Education vigorously promotes integration in the last-named sense. It fosters basic researches in those undeveloped fields which lie between established disciplines, and it tries to impress educators with the need for integration on the deepest plane. Consensus with respect to detailed beliefs, uniform acceptance of facts are not its goal; rather, it councils agreement with respect to criteria of validity, to methods for obtaining facts and to general principles active in nature and in life, agreement which actually exists and is never dangerous.

During a survey of their work before a group of educators in New York City, the officers of the Foundation for Integrated Education were asked to plan a course, designed for men actively interested in education, in which these ideas were

developed and put to test. New York University, with admirable understanding and sympathy, offered its hospitality through Dean Paul A. McGhee and the Division of General Education.The course is also accredited through the University's School of Education for graduate credit. The course bears the presumptuous title: The Frontier of Knowledge, and proposes to deal with integrative concepts of science, philosophy and education.

It presents no formula, hidden or patent, for integration. Nor does it advocate a unifying philosophic system. The course is a modest attempt to show that, when the crucial questions of our age are presented simply, in non-technical terms but with stress on their wider implications, the result upon the teachers and on the students can be integrative. This integration would derive its meaning and support from the principles and the natural order, assumed by science as the source of its validity, which are progressively revealed by its methods for obtaining valid concepts.

More specifically, the course will do three things. First, it will define and elaborate the most central concepts, the potent key ideas which animate present-day researches. It will *expose the various dynamos in the powerhouse of our civilization.* Secondly, it will *show the vistas leading from one discipline to another.* This is in fact an immediate consequence of the preceding aim, for every principle capable of truly illuminating a single field provides such vistas. Thirdly, *the course will present a contemporaneous outlook over several different disciplines.* One of the major obstacles to integration is an anachronistic tie-up between subjects. Contemporary biology is often coupled with the mechanistic doctrine peculiar to nineteenth century physics. Modern psychology uses outmoded chemistry; the twentieth century historian falls back either on Newtonian dynamics or on classical thermodynamics in the attempt at appraising the scientific qualities of his discipline. The physicist is guilty of using the psychology of a past age, and the educator still thinks that pragmatism is the only philosophy consonant with modern science. Each of these mismatchings produces its own litter of paradoxes which cleave our culture and cause it to disintegrate.

The material presented in the following pages is meant to amplify the lectures in the course. It does not compose a textbook and is not expected to be readily understandable in its entirety without the benefit of the lecturers. Much of it is drawn from the writings of the teachers; this is natural in a situation which called, in its choice of teachers, for the very men who have displayed an interest in basic integration. It will also add a more personal flavor to the discourse. On cursory reading, unity between the contents of the various lectures may at times seem to be lacking. This is unavoidable because the present book is also intended to be a provocation to the teachers themselves, a challenge to unify their views and to provide in their oral performance what may be wanting from their writings.

Limitation of course time has made a selective treatment necessary. The subjects chosen for comment are primarily those having a background in deductive theory, a trait which in itself lends them a certain degree of coherence. Omission of disciplines having more descriptive or correlational character is not to be construed as an adverse judgment of their importance. For we believe that an equally interesting and equally integrative account could be given of statistical methods and their use.

Roughly, the first part of this book is devoted to physical and biological science and its methodology. The second part concerns the nature of man and endeavors to draw from the first whatever lessons it holds for the process of education and its philosophy.

Acknowledgment for help in the enterprise is due many persons who, by comment and contribution, have given it birth after the almost incredibly short gestation period of one summer. But the actual selection, compilation and writing of the material in this volume has been the work of Mr. Robert Whorf, West Virginia University, and his wife, Margaret Whorf. Their devotion to the course has been genuine and unstinted. If the course should turn out to be successful, it will be a testimony to their insight and skill.

HENRY MARGENAU, *Chairman*
F. L. KUNZ, *Secretary*

The importance for the development of science in the West of the mechanical view of Nature can be grasped only when it is noted that practically the entire effort of explorers in all fields of science for two centuries was devoted to the application of the principles enunciated by Galileo and Newton. Even the presuppositions of many outstanding and influential philosophers (note, for example, the effects of Locke on the American concept of democracy or of Kant on German nationalism; cf. Northrop, *The Meeting of East and West*) were those of the Newtonian mechanics.

The result of this influence was an extraordinary degree of unification in outlook and effort during these centuries.

Events beginning in the late 1800's, however, and extending to the present century, have conspired to destroy the foundations upon which the classical structure had been built. Any new synthesis to be built must rest on the gains of what is currently verified scientific theory. — *From supplementary readings for Lecture 2, "Mechanism and Space-Time," to be given by Professor Henry Margenau in the Course in Integrative Concepts.*

MOTIVATION AND NEED FOR THE COURSE

F. L. Kunz

Foundation for Integrated Education

I

The process which we may call the transfer of experience through generations by some form of training is as old as man. In fact, if the phrase be severely restricted, it applies to a pre-human phenomenon of life. Education, the more or less self-conscious and higher form of learning, is more recent, although of immense antiquity. Through it the race expresses, conserves, and enlarges its capacity to classify, codify, and compact cultural wealth, and thus facilitate creative originality and the evolution of society.

Education can go on in any political form. The process is always essentially the same, the controls and purposes being variant. In recent centuries, however, entirely new intellectual events have occurred to make utterly fresh demands on this socially most basic of all disciplines, and in recent decades social and political events have made other demands. Teachers responsible for the higher learning, in this country and many others, have recently become aware of a peculiar and acute crisis in their profession. The present course of study is intended to be a new response to those intellectual and social needs. If our purposes here are to be understood, the necessities under reference must be identified.

Republican democracies have survived for periods of time in various places and epochs. They appeared in ancient India; they can be visited among the indigenes of modern New Mexico. History shows us that, in between, lesser and greater states have achieved various measures of response to the popular will. The maintenance of these societies has always depended upon some degree of literacy in some groups of the citizens. Hence there has always been a correspondence between educational efficacy and social stability.

A new situation has now developed. Modern democracies embrace immense populations. They command material techniques which require almost universal literacy. The diversity of subject matter is so vast as to have become unmanageable. As we have come to learn more of the parts, we have inclined to understand less of the whole. As last it has come to pass that we are no longer sure what human existence signifies and the very existence of modern republican democracies is threatened not alone, or perhaps not even chiefly, from without, but from failure within. To serve our society, we have to ensure that so many thousands read blue prints even if no one reads Plato. The construction of guns seems more important than the content of Gospels.

These dismaying discoveries began to be important throughout American education one or two generations ago. We realized we had been making our citizens literate at the expense of learning. Out of the soul-searching came the general education movement. Accounts of the many valiant struggles by faculties to restore proportion are exemplified in such books as *The Idea and Practice of General Education,* an account of the College of the University of Chicago, by present and former members of the faculty (University of Chicago Press, 1950) or *General Education in a Free Society,* the Harvard Report of 1942.

This healthy stirring uncovered that most peculiar feature of our contemporary circumstance, in respect to education, which is the real origin of this course of study. Innumerable faculties made efforts to go beyond the sampling and re-balancing of general educational courses toward courses of study intended to be integrative in effect. The more serious were these efforts the more certain was it that *science* proved to be both the obstacle and the hope of cultural synthesis, common understanding, and high purpose.

A number of important considerations, long more or less understood, thus became quite clear. They deserve enumeration, since it is these which lead to a new kind of educational understanding. Each will be quite familiar taken singly. Together they constitute a novel demand upon us all. They are (1) the emergence of the concept of energy, and later its ascendancy over the concept of matter; (2) a similar development and accentuation in reference to field concepts; (3) the recognition of a structural space-time geometry; and (4) the stubborn challenge of so-called "particles" (i.e., quanta).

Our concern is with those holistic[1] elements in science, and especially the new science, which are meaningful for cultural synthesis. The reasons for certain disordering compulsions which the discipline exercises upon society will be made evident, incidentally, as our studies proceed. Here it is enough to say that these disorders are inevitable and will increase, until the cultural meaning of science, not alone the products of its ingenuity, is made commonly available. Every gain in understanding and mastery of nature, without comparable gain in understanding and mastery of self and society, implies new problems. Newspapers are a benefit and a menace, so are radio and television, the telephone, the automobile, not for reasons in themselves but in ourselves. We do not know clearly enough and unitedly enough what human existence is for, and hence we do not know whether the bomb is for man or man is for the bomb and (if so) which man. We shall

[1]holistic - Gk: *holos,* complete. A term put into currency by J. C. Smuts to convey the notion of a philosophy of the whole.

never know these things so long as we know so much of matter and energy and so little about life and man. How are we to deal with this problem in a fashion suited to the enlightenment of free men, not to the indoctrination of slaves?

II

In the last century decisive changes occurring in most departments of science, and accelerated since 1900, display remarkable promise. This promise is evident only when the meaning of the changes, in their totality, is disclosed. We appear to be in the midst of one of those periods of vast intellectual transition which, in retrospect, will prove to be the opening of a long period of ripening of a few relatively simple and genuinely universal principles. Can we not anticipate what some of these major consolidations will be?

Certainly one leading feature is the growing importance of understanding wholes in order to master parts of nature. As a tendency, this goes very much further than we are able as yet to extend exact-deductive science, but encourages hope of such extension.

The physicist describes the behavior of a small magnetic compass in terms not of local conditions alone, but of the earth's entire magnetic field. Such developments deepen the biologist's convictions about the primacy of his concepts of organization. Meantime in Gestalt psychology evidence is offered that meaning itself is derived from wholes.

Again, physics has relegated the sort of materialism natural to mechanics to a philosophically subordinate place. If the physicist is asked what it is which takes the place vacated so largely by matter, he speaks of ordered events, geometrically structured systems. Terms like these are most acceptable for the biology of organic development and to a maturing science of psychology.

Finally, the order which has come forward to take the place vacated by crude materialism emerges from a background structured in a strange fashion of time and space conjoined. The "Mother of all living," relativity tells us, is not a mythical goddess but a cosmic geometry.

> "In Einstein's theory of gravitation matter and its dynamical interaction are based on the notion of an intrinsic geometric structure of the space-time continuum. The ideal aspiration, the ultimate aim, of the theory is not more and not less than this: A four-dimensional continuum endowed with a certain intrinsic geometric structure, a structure that is subject to certain intrinsic purely geometrical laws, is to be an adequate model or picture of the 'real world around us in space and time' with all that it contains, and including its total behavior, the display of all events going on in it." [2]

Now more than ever the mind of man has extended precise knowledge much further than his vision; his reach has exceeded his grasp. He knows of properties beyond immediate experience and even impossible to picture, but necessary to accept because Nature embodies them in her manifest works. Some scientists even go so far as to say that a species of superphysical reality is already implied in the present concept of space-time.

This departure from old-style materialism suits biology, as we shall subsequently see, and it promises to be vitally important to new developments in psychology and sociology. All of these disciplines are conscious of needs of good field theory for their own data. This demand is made by an increasing number of workers in psychology, particularly in parapsychology, and in sociology, particularly by the contributions of Kurt Lewin. What they may require of "fields" may or may not coincide throughout with the concept as it is used in physics.

> "Broadly speaking, in physics the term 'field' is referred to the continuous distribution of some 'condition' throughout a continuum. The precise nature and magnitude of this condition varies greatly and is to be determined by an analysis of a particular problem." [3]

The world's confusion, violence, and soul-suffering, however, will not be alleviated until the new meanings of science are conjoined with those of art, ethics, and every other cultural mood.

The question therefore is whether the ultimate moral meaning of objective science is or is not the same as the springs of spiritual being in man's existence.

What bearing on this supreme issue can we derive from the fact that the external world has non-material aspects, is a whole, and a projection of a space-time of ordered properties? What we need at this point is not some intuitive leap or poetic analogy, nor some happy re-interpretation of scriptural lore. We have seriously to ask whether the sober mathematics of Einstein and Minkowski mean what Shakespeare tells us through Portia: "the floor of heaven is inlaid with patines of bright gold." The poet did not know, as we can know, that a four-dimensional world of space-time gives rise to winking galaxies, but he has something beautiful. Will his beauty and science's truth turn out to be consonant?

All that is to be seen, and all that is but a means to an end. First we must ourselves know what the scientists mean. When we have found out what these new meanings of science are, we may inquire what constitutes "a good deed in a naughty world." At present even men of good will no longer know how to do right in a world re-made, and mis-made, by a science whose physical works excite, overwhelm, and now threaten to destroy them. The

[2] E. Schroedinger, *The Structure of Space-Time.* Cambridge, 1950.

[3] R. P. Whorf, *Main Currents in Modern Thought.* 6 (1949) 70.

concepts which made possible the technology which led to these changes have been denied to us, and we suffer the effects without understanding the causes. Some of us are convinced that in those concepts is a vast potential for new understanding. We propose to acquire and use the resources now locked up in technical forms of science.

If so much can be agreed upon as common hope, certain practical problems arise and must be solved.

III

What should be an outcome of this program of studies, not after a few months but some years hence?

Societies are held together by many forces, including a common outlook. There can be no world society until there is a world consensus, not with respect to specific doctrine but with respect to laws of nature and to major values. If the consensus is firm and fundamental, the solidarity of the race will be increased and may long endure.

For such purposes a comprehensive philosophy faithful to science is ideal because science itself is coin of the realm for the modern world.

What is its authority?

That question can be answered by a simple illustration from chemistry. Everywhere the chemist consults the periodic table as an established body of doctrine. Here in a small tabulation certain dependable properties of all the matter in the entire universe are laid out in tabular form. Behind this table of the elements stands a solid structure of concepts subject to public demonstration. This process of establishing agreement, and the information agreed upon, constitute the ideal authority for a democracy. There is no occasion to fear it, in itself, since new findings prevent dogmas from stifling the developments of scientific concepts. But if these undogmatic, publicly established, valid concepts are to contribute to a world-wide consensus, every effective citizen must achieve, in common with every other effective citizen, an adequate grasp of the concepts themselves, as well as some grasp of the methods employed in establishing them. The people who understand the periodic table have agreement on the point that the *matter of the universe is orderly in itself*. When such knowledge of the cosmos is sufficiently extended to develop in biology and human affairs a comparable certainty about order as now obtains in physics and chemistry — a matter of research — the beginnings of a world consensus will have been achieved.

If there are those who believe this will impair freedom, let them observe what disasters threaten us because we now have a consensus badly based and grotesquely disproportioned.

The program of research into key concepts and their formulation in a style teachable to all amounts to improvement of our cosmological ideas. A few men in medieval Europe were convinced of the roundness of the planet at a time when the populations generally were flat-earthers. The few acted on their knowledge and made discoveries which destroyed the foundations of the economy, the political systems, and the cosmology of the continent.

A few men now know the new scientific features of our universe. They are acting upon this knowledge, and what they do may threaten to destroy the modern world. We need to possess the cosmological gains latent in the new ideas. The real obstacle to the new achievement is not the difficulty of the concepts. They can be elucidated in non-technical terms and can therefore be taught widely. The difficulties exist only because our society does not yet realize that the truly practical man today is the socially conscious philosopher, not the narrow-gauge and short-visioned person who mistakenly supposes that we can cure the world's anxieties and torments by symptomatic treatment using remedies of the past, which scarcely even alleviate them.

Finally, we would do well to confront what appears to me as an important fact. Modern thought resembles more and more certain philosophies of antiquity. This constitutes a remarkable advantage, for it means that the successful formulation of the concepts natural to our present-day science may possibly bring the nations together and ensure a meeting of minds.

> ". . . Modern science . . . mathematics and physics make the world appear more and more as an open one, as a world not closed but pointing beyond itself. Or, as Franz Werfel expresses it in pregnant wording in one of his Poems, '*Diese Welt ist nicht die Welt allein*'." [4]

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[4] H. Weyl, *The Open World.* (New Haven, 1932).

RESEARCH IN THE LOGIC OF VALUE*

Robert S. Hartman

Ohio State University

It has been recognized by philosophers for some time that the only way to bring order into the present chaos of social sciences — and hence the world of human relations — is a systematic analysis of the kind of judgments by which social sciences differ from the natural sciences, namely value judgments. This quest into the meaning of value is of relatively recent date. Until about a hundred years ago neither the natural nor the social sciences existed. Both were part of philosophy. (The title of Newton's book was *The Mathematical Principles of Philosophy,* and Faraday hated "the new fangled term physicist" and insisted that he was a "natural philosopher.") Laboratory instruments until that time were called "philosophical instruments." Philosophy was divided into two fields, natural philosophy and moral philosophy. Natural philosophy has since developed into the *natural sciences,* moral philosophy into the so-called *social sciences.* Only ethics, aesthetics, logic and metaphysics have remained within the field of philosophy proper.

Whereas the development of the natural sciences has led to control of natural phenomena, the development of the social sciences has not led to a corresponding control of social phenomena. On the contrary, the social forces are today more out of hand than ever. With the help of the extended scientific tools, they are in danger of destroying society itself. What is needed, therefore, is a scientific development of moral philosophy similar to that of natural philosophy.

The philosophers who designed the natural sciences did so in two ways: (a) by developing a powerful tool which served as the method of the sciences, namely, the pure science of mathematics; and (b) by designing frames of reference for each realm of phenomena and confining their inquiry to the particular frame of reference in question. These philosophers saw that the book of nature was written in the symbols of mathematics, but in their time mathematics did not exist and they had to design the tool as they went along. Gradually pure and applied mathematics separated. The pure mathematicians further elaborated mathematics and on the simple foundation of a few basic axioms, by analysis and by induction, built the structure of arithmetic, algebra, analysis, and the various new forms of mathematics, such as calculus of matrices, topology, etc. In this way mathematics became a pattern of all kinds of possible frames of reference. From it applied scientists borrowed freely, thus fitting their observations into appropriate mathematical frames. Thus astronomy used the calculus, differential and integral equations, and later non-Euclidean spaces; electrical theory used the science of complex numbers; quantum theory borrowed the matrix calculus; thermodynamics the calculus of probability. This meant — and this was the second important fact in the development of the natural sciences — that each frame of reference had its own laws and significance. Natural philosophy split up into physics, chemistry, biology, astronomy, etc., but all the sciences, different as they were from one another, partook in the pure super-science of mathematics.

Today the knowledge of nature, elaborated in mathematical science, has led us forcefully to the necessity of moral science. Moral science is based not on quantity but on quality, not on measurement but on valuation, not on inference but on preference. The natural sciences concerned the behavior of things; moral science concerns the behavior of men. The question is how this science can be developed to similar heights.

There must be a pure science which is to the social sciences as mathematics is to the natural sciences; it must be formal and universal, built on simple axioms, and contain all possible frames of reference for the social sciences. Such a system would be the logic of the social sciences, just as mathematics is the logic of the natural sciences. The task, then, is to find a logic of value judgments, or "axiology."

Value judgments are judgments in which appears the word "good." Just as mathematics can be built on the definition of the term "number," so axiology must be built on the definition of the term "good." The problem then comes down to the question, what is the definition of "good"?

It was my hypothesis that "good" must be a logical term. But neither the traditional "definitions" of "good" — pleasure, happiness, the one satisfaction, the greatest happiness of the greatest number, growth, self-realization, sympathy, union with God, loyalty, reason, the fitting, — nor its characterizations, as ontological, illusionary, like the sun, a feeling, a sense, could fulfill the hypothesis. One modern philosopher who tried a logical approach began and ended his quest with the dictum that "good" was indefinable.

The situation then was similar to that in mathematics until Gauss. For twenty-five hundred years

*A brief informal description of a research project formulated by the author and approved by the Council of the Foundation for Integrated Education.

— from the Pythagoreans and Platonists down to Leibnitz — number was regarded as a moral and metaphysical entity. Gauss, who through the invention of complex numbers succeeded in dispelling the last archaism in number theory, still spoke of "the metaphysics of the number $\sqrt{-1}$"; and it took another hundred years until the logical nature of mathematics was established.

The term "good" is still regarded as a moral and metaphysical term, although it is obvious that *a good road, a good gun, a good horse,* or even *a good bookkeeper* are not good in a moral or metaphysical sense. Theory of value, as Susanne Langer has rightly said, is still archaic. I therefore decided to make the word "good" my research project. It proved to be an elusive one. Anything, it turned out, could be good — that is, "good" could be predicated of any subject whatsoever. Other adjectives have realms of application; "virtuous" cannot be applied to shoes or TVA, nor "yellow" to honesty, God, or digestion. "Good" can be applied to all these. It is ubiquitous, like the words "a" and "the." This seemed to confirm the hypothesis: "good" behaved like a purely formal term. But what was it? The only way to proceed was by a kind of induction, collecting samples of "good" and trying to sift out of its uses the one ingredient — if any — they all had in common. Whenever I heard or read the word I noted its use. Soon I had scores of samples. In the Oxford English Dictionary I found 135 uses, and in Grimm's Dictionary of the German Language 528 quarto columns. When finally the solution presented itself, it turned out to be a formal and logical one. In addition, it was extremely simple. It now seems difficult to see why it should have taken so long to find it.

The solution is as follows:

Good is the predicate of a subject which fulfills its definition. One way to explain this is the story of the three judges and the three final contestants in a poodle show. Which poodle would get the prize and be "the best"? There are here not three poodles but six, the three actual poodles and one poodle each in the mind of each judge which for him constitutes the ideal poodle, or the definition of "poodle." (Some people add another nine poodles, namely the images of the three poodles in the mind of each judge.) That poodle will get a judge's vote which most closely resembles the ideal poodle in the judge's head. Expressed in more exact terms, *"x is good if x is the member of a class C and has all the attributes of C."* A doctor is a good doctor if (a) he is a doctor, that is has passed the State Board, and (b) he has all the attributes of a doctor, that is knows medicine. Simple as the solution is, it is logically difficult; particularly the word "and" in the definition opens up problems in the foundations of logic which modern logicians believed to have interred forever. This is no wonder, for modern "logic" is constructed strictly for one purpose: to account for mathematics. Axiology shows up the speciousness of the claim of mathematical logic to be "logic" pure and simple.

The definition of "good" leads to the definitions of "no good," "not-bad," and "bad." "No good" is the predicate of a subject which does not fulfill its definition; "not-bad" is the predicate of a subject which partly fulfills its definition; and "bad" is the predicate of a subject which partly does not fulfill its definition. In predicating of the subject all, no, some, or some . . . not attributes of the definition, the terms "good," "no good," "not bad," and "bad" stand to definition or intension in a relation which is analogous to that in which the terms "all," "no," "some," and "some . . . not" stand to extension. They produce axiological propositions analogous to the four kinds of traditional propositions (A, E, I, O) and function as "axiological quantifiers." The axiological "copula" is "ought." It expresses the relation between partial and complete fulfillment of the definition. What is bad ought to be good. "Ought not" expresses the converse relation between complete and partial fulfillment of the definition. What is good ought not to be bad.

On these simple foundations the science of axiology can be erected, leading to a calculus of extrinsic and intrinsic value, value classes, value relations, truth values of axiological propositions, a calculus of choices, of agreements and disagreements, of polls and parliamentary procedures, and a systematic of the social and humanistic sciences. The research now being undertaken concerns the logical foundation and elaboration of axiology and its application to the social and humanistic sciences.

. . . it is not the *character* of the constituents of a living thing but the *relations* between them which are most significant. An organism is an *organized* system, each part or quality so related to all the rest that in its growth the individual marches on through a series of specific steps to a specific end or culmination, maintaining throughout its course a delicately balanced state of form and function which tends to restore itself if it is altered. This is the most important thing about it. — Edmund W. Sinnott, *Cell and Psyche* (Chapel Hill, N. C., 1950).

GOETHE'S CONCEPT OF NATURE*

Ludwig von Bertalanffy

University of Ottawa

The Dawn of Morphology

"I found neither gold nor silver, but something that gives me unbound satisfaction, the intermaxillary in man." In these words Goethe jubilantly informed Herder in March 1784 of a discovery which he didn't consider second to his work as a poet. What was its importance?

In mammals, the upper incisors are imbedded into a bone, known as the intermaxillary. Only *one* organism, so it was believed at that time, makes an exception, namely, man. The apparent lack of an intermaxillary in man was regarded as a proof of his singular status in the world of the living. Goethe, however, in his conviction "that every part of organization should be found in all animals," searched for traces of the intermaxillary in man and had, as he says, little difficulty in finding them. The basis of Goethe's discovery was a deep conviction in what the French zoologist Geoffroy St. Hilaire twenty years later called "the unity of design" in living beings. The feeling of having traced that unity of nature deeply excited the poet and led him to consider his finding as more than a mere zoological fact.

Goethe's discovery marks the beginning of a science which he called morphology, the theory of living forms. The manifoldness of forms encountered in the animal and plant kingdoms is considered to be variations of only a few basic designs or types. Thus, the different shapes of the mammalian skull, from the harmonious dome of the head of man to the skull of the horse, the elephant, and even the grotesque *Sus barbirussa,* appear as variations of one basic design. Following this conception, Goethe, and later Oken and others, searched for a primary basic element of the skeleton. Goethe believed he had found it in the vertebra. According to the vertebral theory, which has been given up to-day, the skull consists of a number, perhaps four, of transformed vertebrae. In a similar way, the forms of plants are regarded as variations of an ideal or primeval plant, the *ur*-plant of Goethe. The leaf is regarded as the basic element, the metamorphosis of which leads to the formation of the different organs, such as cotyledons, green leaves, calyx, stamens, and pistil. Similarly, the abundance of forms within the plant kingdom is considered to be different transformations of one and the same basic design and primary element.

In later days — after Darwinism had been generally accepted — Goethe was regarded as a precursor of the theory of evolution, the doctrine that "higher" organisms have descended from "lower" ones. This is a misunderstanding. The writings of Goethe show few hints that he has thought of descent. For Goethe, the basic design or type is not an ancestral form which existed sometime in the geological past, and the descendants of which are the organisms of the present. Rather the "type" according to Goethe is an ideal structural law, expressing itself in the various organic forms. It is, in his words, an ideal archetype containing potentially the manifest forms of animals and plants.

The history of morphology shows ups and downs as they are found so often in the history of science. The first half of the nineteenth century is the golden age of classical morphology, or typology, as we may call it after its basic concept. The great ground-plans of the living world are elaborated, and so the work of the leading investigators of this period, such as Reichert, Karl Ernst von Baer, Owen, and others, is essentially the execution of the program set by Goethe.

The appearance of Darwin's *Origin of Species* in 1859 marks the triumphal advance of the theory of evolution and the beginning of the modern age of biology. Linné, the great taxonomist, declared the multiplicity of animal and plant species to be the work of individual acts of creation. Even the great Cuvier, in the beginning of the nineteenth century, explained the changes in the animal world as a result of a complete destruction and new creation of the organic world in each geological epoch. Now the cosmic perspective of natural evolution was opened. The typological system, arranging the organisms according to the conformity of their basic design, is replaced by the genealogical tree, the descent of higher forms from lower ones. The ideal archetype is replaced by the ancestral form which actually has lived in some past epoch, and whose transformed descendants are the later and modern forms.

Haeckel, naïvely enthusiastic about his monistic world view, claimed Goethe to have been a Darwinist before Darwin. He was wrong in doing so — as pointed out before — although we may assume that Goethe would have been an evolutionist if he had had the knowledge of modern biology. In general, however, the world picture of the second half of the nineteenth century and the explanation it offered for evolution was not the fulfillment, but rather the destruction of Goethe's world picture.

It was that world view which is usually denominated the "mechanistic." The ultimate reality was sought in physical processes obeying strict laws of nature, but void of directiveness and sense:

*Translated from *Atlantis Verlag,* Zurich, August, 1949.

the "blind play of the atoms." Thus, it is the task of science to resolve the complex objects and processes of nature into elementary parts. The summing-up of these events as established by analysis and isolation will give an understanding of the phenomena in inanimate nature as well as in animate nature. The same conceptual scheme is used in Darwinism in order to explain organic evolution. The organisms undergo incidental changes, called mutations in modern terminology. They are eliminated or favored in the struggle for survival, according to whether they are detrimental or useful. In the latter case, they lead, in the course of many generations and long periods of time, to the phylogenetic rise in organization, as well as to the progressive adaptation to different environments. Form and organization in the living world thus appear as products of factors working at random in hereditary change and in selection. In this way, the elementaristic and utilitarian conceptions are basic in the mechanistic world picture, and they are closely connected with the general *Zeitgeist* of this era. The theoretical procedure of classical physics, the triumph of technology and of the machine, the corresponding conception of organisms as living machines, the Malthusian problem of over-population leading to struggle for existence in human populations as well as in biological communities, and the principle of free competition in national economy are all different expressions of the same general view.

The dissatisfaction with this view has led to the cry, "Back to Goethe." First, it was heard in biology. It is a trivial fact that organisms are organized. Modern biology finds in a great variety of problems that the elementaristic orientation, the resolution of organic structures and processes into isolable units, be it chemical building-stones, cells, reflexes, or genes, misses the integrative principle of vital organization and wholeness. The marvellous architecture of living organisms, the abundance of forms that apparently surpasses the exigencies of mere survival, is felt to be insufficiently explained in terms of random mutations, their usefulness and selection. A morphology in the Goethean sense, the primacy and autonomy of which is claimed with respect to the theory of evolution, is offered as another alternative. Actually, what we are able to state is the unity of design within groups of organisms and the correspondence or homology of their texture. Making this grouping into a phylogenetic history is a hypothetical and often rather dubious interpretation.

Corresponding problems are popping up in many and varied realms. Classical physics tried to resolve the world into a senseless play of mass-points. Its laws, the second principle of thermodynamics in particular, are laws of elementary disorder. In modern physics, however, problems of organization with respect to the atom, the molecule, and the crystal are the most fascinating ones. In chemistry, problems of design and structure are basic, as shown already in isomerism: chemical compounds consisting of the same atoms but in different arrangements may exhibit very different properties. It is the structural plan which is often decisive. For example, such general structural plan is apparent in the various protein molecules of the organism, though this "mold" may be filled by different component chains, amino acids in this case. This structural plan is found in the thread molecules of silk as well as of the hair, of the muscle, or of fibrinogen which is responsible for blood-clotting. In certain cases, this structural plan is of decisive practical significance. Thus, the chemotherapeutic effect of the sulfa-drugs is probably based upon the fact that they correspond in their structure to certain growth-promoting substances in bacteria; therefore, they can displace the latter, inhibit bacterial growth, and stop the infectious disease.

Gestalt and wholeness, intuitively conceived by Goethe and denied in the mechanistic world picture, thus re-appear as a central problem. At the same time, however, the *gestalt* concept appears to be very problematic and even dangerous. Let us go back for clarification to the biological field as its center of origin.

We have, on the one hand, the mechanistic view, elementaristic, dissolving form and organization, conceiving the living organism as a product of summation of chance variations. To overcome this dreary picture, we are offered the concept of *gestalt*. *Gestalten,* such as the *ur*-plant and the fundamental plan of the skull are, according to Goethe, "ideal archetypes." What does that mean? Apparently that in a super-physical world, that of the "Mothers" in *Faust,* platonic ideas are pre-established, after the paragon of which the physical world is formed. This conception, however, is diametrically opposed to the principles of modern empirical science. There is only a small step from this Platonism to Aristotelianism. If the "ideas" are not only hovering in a super-physical world but determine physical nature, then they must be factors or entelechies active in real things, and the living organism in particular. Then the system of modern science, which has given us not only theoretical knowledge of nature but has led to the triumph of modern technology, is basically wrong. For the system of physical forces and laws is superseded by other agents, hobgoblins, as it were, who direct the events toward a secret goal, organization and wholeness. This is the conception called "vitalism," and rightly discarded in biology, because it contradicts empirical evidence, and even threatens its very foundations.

This is the antithesis from which the dispute about Goethe and the meaning of morphology has arisen. Hence it can be understood why the scientist is hesitating to accept the notions of *gestalt,* typology, and the morphological point of view.

This was stated perhaps most clearly by the paleobotanist, W. Zimmermann. According to him, typology is intuitive, subjective, and at best valuable only at a pre-scientific level. The typological relations between organisms are nothing real; what are real are only the phylogenetic connections.

If we want to come to a clarification we have to return to Goethe himself.

The Meaning of the Ur-plant

In a famous conversation in July 1794, Goethe claimed to be able to sketch the *ur*-plant in a few lines. He was embarrassed and disappointed by Schiller's answer that the *ur*-plant was not an experience but an idea which as such never could be found in experience. He put himself together, however, and told Schiller that he was glad indeed to have "ideas" without knowing it, and even to see them corporally.

Here we have the key to Goethe's conception. Goethe was an eidetic type, and his pictorial imagination was indeed the basis of his greatness as a poet. As he tells us, he was able to produce voluntarily and magically, as it were, pictures of patterns, plants, and landscapes, behind closed eyes. At a significant crisis in his life, the farewell to Sesenheim, he saw his double facing himself. Similarly, the *ur*-plant is for him an object of intuitive experience. The same is true of the "*ur*-phenomenon" which he finds in his theory of colors and other natural phenomena. Just as a musician may pursue a theme through a world of variations, and it wouldn't make any sense to ask whether the original theme had been "real," or whether it is the platonic idea of its variations, so the eidetic archetype of organic forms can be varied in different ways. However, Schiller, an abstract type, pins down Goethe's intuitive experience as being an "idea." In this way, he involves all those problems which were discussed by the scholastics of the middle ages under the head of the problem of universals: the question of whether universals are real as platonic archetypes, are only arbitrary abstractions or *flatus vocis,* or are in some way pre-established in the phenomena. Goethe, the poet, cares little about the logical status of his "ideas," and in this respect he is not so far from the modern scientist who also is faced with the age-old problem, though hardly realizing it. For the question of the "reality" of "types" is logically identical with the question of the "reality" of "laws of nature." Also the latter do not roam freely in nature: they are a fabric of logic relations, describing and emphasizing only certain traits of reality. Thus, it is no objection against Goethe's concept of "types," and no demonstration of their purely subjective character that the types, according to his statement, are never fully realized in experience. For the same is true for every law of nature which also is an idealization of reality, only approximately realized under the isolating conditions of the physical experiment, or as a statistical average within a collective embracing many individual events.

It is therefore not correct to state that typological relations are merely subjective and phylogenetic relations alone real. The statement of homology of organs within a typological groundplan and the typological system of organisms are groupings based upon relations found in nature. It is the same as in the natural system of the chemical elements after Mendelyeev and Meyer which is a natural grouping (and even was before it found its explanation in modern atomic physics), although this system does not speak of "phylogenetical relations" of the elements which actually were believed to be unchangeable at the time. Morphology is a simple description of objective relations, and has nothing to do with platonic ideas. Even more: morphology is a necessary prerequisite for later explanations. Thus, the typological grouping of the elements was the basis for the later development of atomic physics. Similarly, the typological system of organisms is basic for the theory of evolution. In a similar way, Spengler's and Toynbee's tables, indicating the parallelism of phases in different civilizations, may be right or need correction according to factual evidence; but they are statements about the morphology of cultural evolution, and independent of Spengler's metaphysical conception of the "soul of culture" or other philosophical interpretations. Morphology and typological order are autonomous and necessary scientific methods.

Thus, one part of Goethe's conception of nature is ascertained, that part which is most in vogue to-day. Adopting the necessity of the morphological conception we realize, however, that it does not give a deeper understanding as compared with the conventional method of science. Rather it remains at the level of description and grouping of factual data. The basic problems of wholeness and organization are not solved by the morphological approach. But what our time is striving toward is a system of science which does not, as was the case in the mechanistic view, deny and discuss away those problems but rather integrates them into the edifice of the laws of nature. We need an exact science dealing with wholeness and organization.

Goethe's Dynamic Conception of Nature

It is also easy to see that Goethe's notion of the "type" was not platonic for a different reason. His *ur*-plant is not an immutable archetype, but rather, as he puts it, an eternally changing proteus. Being himself a paragon of Faustic Man, Goethe could not be a Platonist, and could not conceive the core of reality in stable forms, throning beyond time like the marble statues of the gods. Behind Goethe's apparent Platonism lies the Heraclitean view; behind the manifest form, a never ending stream of becoming; behind the morphologic intuition, its resolution into dynamics. In the Be-

ginning was not the Word, in the Beginning was the Act.

Goethe's world picture forms part of a great evolution of occidental thought. This evolution starts with Heraclitus who, unfathomable and at variance with the Apollinic world-view of his contemporaries, was called "the Obscure" at his time. It continues to German mysticism, the last culminating figure of which, Nicholas of Cusa, opens, at the same time, the era of modern science. From here, the line goes as well to the sombre mysticism of Jakob Boehme, as to the enthusiastic philosophy of Giordano Bruno and to Leibnitz' lucid mathematics. Finally, and over a long road, it leads to modern physics which again resolves matter into a stream of events.

"State is a silly word; for nothing is fixed and everything is mobile," Goethe wrote to Niebuhr in 1812. "Everything must decay into nothing if it wants to persist in being. It is *laws* that preserve the living treasures that adorn the All" (*Vermaechtnis*). What is persisting in change is not a Platonic archetype, but the dynamic law in the phenomena. Or, as Goethe puts it, in anticipation of modern criticisms of the mechanistic view: "There will be a time when the mechanistic and atomistic conception is abandoned by all good thinkers; all phenomena then will appear to be dynamic and chemical, and thus confirm even more the divine life of Nature."

Goethe's conception of living nature is even more pronounced: "Looking at all the forms, and in particular at the living organisms, we see that there is nowhere anything static, resting or closed; everything fluctuates in an eternal movement."

Heraclitus' saying, *"metaballon anapauetai,"* was interpreted by Zeller (1883) as follows: "Things appear to remain the same as long as from one side the same amount of a certain material flows in as is lost at the other side." Again, the basic characteristic of living systems, the profound significance and laws of which are realized only in recent developments of biology, was formulated by the father of modern physiology, Johannes Mueller, himself a disciple of Goethe: "As long as an organism lives, it is in a state of continuous decay, consumed matter perpetually being replaced by new matter." Let us compare two modern quotations:

"The discovery and the description of the dynamic state of the living cells is the major contribution that the isotope technique has made to the field of biology and medicine . . . The erosion of the cell structure is continuously being compensated by a group of synthetic reactions which rebuild the degradated structure. The adult cell maintains itself in a steady state not because of the absence of degradative reactions but because the synthetic and degradative reactions are proceeding at equal rates. The net results appear to be an absence of reactions in the normal state; the approach to equilibrium is a sign of death" (Rittenberg 1948).

"Every organic form is the expression of a stream of events. It is maintained in a continuous change of its components. Every organic system appears to be stationary if considered from a certain point of view. If, however, we go one step deeper this maintenance implies an incessant change of systems of the next lower level: of chemical compounds in the cell, of cells in the multicellular organism, of individuals in the supraindividual units of life. Therefore, we can view organic forms not only as expressions of an ideal ground-plan as it is done in idealistic morphology, as a result of ontogeny and phylogeny, as in embryology and phylogenetic morphology, we must view them also as the expression of an orderly flow of events, a patterned system of forces. This conception may be called *dynamic morphology*" (von Bertalanffy 1942).

"All forms are similar but none equals the other, and thus the host hints at a secret law" (*Die Metamorphose der Pflanzen*). Classic Darwinism explained the living forms as accidental aggregations accumulated from chance mutations by the exterior circumstances of environment and the struggle for existence resulting. To-day we are led to acknowledge, and progressively to discover, the intrinsic laws of evolution. Again to confront Goethe's formulation with a modern one, we may use the remarkable work by Rensch (1947) wherein he surveys the laws of macroevolution. According to Rensch, there is no reason to assume an autonomous drive towards evolutionary progress in addition to the established factors of evolution, namely, mutation, selection, fluctuation of populations and isolation. However, neither the organization of the animal body nor the environmental conditions tolerate evolution entirely at random. Rather there are restrictions which in many cases work out directly as an "evolutionary constraint."

It is dynamics that gives organic forms their intrinsic necessity. In his fragment on Diderot, Goethe gives a vivid description of how change of one single part, the growing blind of an eye, leads to a change of the body as a whole, of the face, the posture, of gait and behavior. Speaking in modern terms, the most difficult problem of evolution is co-adaptation, namely the fact that a major change in one organ must be, and actually is, concomitant with corresponding changes in the organism as a whole in order to keep it viable. Co-adaptation presents the main difficulty to explanation in terms of the recognized factors of evolution, at least as long as we assume that mutation and selection are simply adding up summative characteristics. As Rensch emphasizes, it becomes accessible to scientific explanation if one considers that the characteristics of the organism are essentially system characters in Bertalanffy's sense, resulting from mutual interdependence. Thus, the essential regularities which modern biology is trying to establish are signally system laws, and their acceptance has nothing to do with vitalism.

As far as this was possible on the basis of the knowledge of his time, Goethe tried to formulate the "secret laws" of organic form and metamorphosis which we are able to-day to define in a somewhat though unfortunately not much subtler way. "The *ur*-plant becomes the most wondrous creature in the world for which Nature herself should envy me. With this model and the

key for it, it is possible to invent *ad infinitum* plants which must be consistent, that is, which if they do not exist, nevertheless could exist." These are almost the same words uttered by Durer, when he studied the rules of proportion in order to be able to invent creatures of every kind "never seen or guessed by anybody before," creatures however not formed arbitrarily, but truly according to divine laws. The method of representation which was used by Durer in his theory of proportion is virtually identical with the theory of transformation as applied by D'Arcy W. Thompson in modern biology, and used for demonstrating phylogenetic relations. Again, Goethe states: "If, according to intrinsic laws or due to external causes, the shape, *the proportion of parts,* in a plant is changed, this is a process according to the law, and no variation is to be considered as a malformation or degeneration." Thus, organic shape is the result of the inter-relation and proportion of the parts. This corresponds perfectly to the insight gained in modern biology. Changes in proportion form an important part of evolution, and their "law" can be stated by Thompsonian transformation or by Huxley's principle of allometry. In this way the ring closes from Goethe's conceptions to those in the modern theory of evolution.

"No animal whose upper jaw encloses a complete set of teeth has ever carried a horn on his forehead; thus Mother Nature never was able to create a horned lion, even by straining all powers. There is not material enough to plant a complete row of teeth and to force antlers and horns in addition" (*Metamorphose der Tiere*). "Nature, being economical and thrifty, has prescribed a budget. She preserves the right of being arbitrary within the individual items; she has, however, to keep up the sum total, deducting from one side what was overspent at another, maintaining thus a perfect balance." In these words, Goethe states his "budget law." In modern terms, it is called "compensation" and derived from the competition of organs for building materials according to the rule of allometry. The importance of this principle for synholistic transformation in evolution has been exposed by Rensch and others.

In contrast to the utilitarian fanaticism, the "huckster's philosophy" of classic Darwinism, as Nietzsche called it (a product of the Victorian style of life and naïve belief in "progress"), Goethe was deeply impressed by the creativeness of living Nature. "Nature doesn't do anything in vain, is an old Philistine saying. In fact, everywhere she creates abundantly and lavishly, so that the Infinite may always be present, because nothing can persevere." It cannot be said that the idea of creative evolution is generally accepted in modern biology; although Goebel, the great botanist, hinted at the abundance of forms of algae or radiolaria, all found together in the sea, in a perfectly homogeneous habitat, and thus obviously far beyond the exigency of usefulness and adaptation. It may be permitted to give a quotation from the present author, supposing that its tenor might be accepted in the future: "The evolution of life appears to be more than a product of chance, directed only by the principle of selective advantage. Rather it seems to be governed by comprehensive laws. Not indeed by mysterious vitalistic factors tending towards increasing adaptation, purposiveness or perfection, but governed by principles into which we have some insight at present, and hope to gain more insight in the future. Nature is a creative artist; but art is neither chance nor arbitrariness, it is the fulfillment of great laws" (1949).

A gifted commentator of Goethe's work has honored the present author in designating the latter's organismic conception as an offspring of Goethe's conception of nature. Seidel (1948) states:

> "Bertalanffy has further developed Goethe's doctrine of the wholeness of the organism. He conceives the organism as a hierarchical order of steady states within a dynamic open system . . . The specific laws of the organic levels are superimposed upon those of the physico-chemical level, but formally not different from the latter. In this way, Bertalanffy shows the way out of the dilemma between mechanism and vitalism of a Platonic-Aristotelian character . . . It seems to us that this is the way biology may follow in accordance with Goethean principles."

Thus, we come to a conception of Goethe's doctrine of organic forms which is rather different from the familiar one. Morphology, as a descriptive science, is, so to speak, only the uppermost layer. Beyond morphology is a deeper layer, the explanation of wholeness and form by their resolution into dynamics and dynamical laws. Thus, form and flux, morphology and dynamics, Plato and Heraclitus are not opposites, but complement each other. Spranger has explained the insufficiency of mechanism as follows: "The idea of the living form, as legalized by Plato, Aristotle, Goethe and Hegel, eternally is at odds with the science of laws and relations between ultimate elements of reality." This is true so long as science remains elementaristic in the sense of the mechanistic world picture. But there is no "eternal" fighting between the science of form and the science of law. The concept of "type" belongs to the level of description; it is to be explained by dynamic laws. Sure enough, almost everything remains to be done in this field. But we believe that a new conception of nature heralds itself which, on one hand, acknowledges form, organization, and wholeness in Goethe's sense, and, on the other hand, subordinates them to laws which are the essence of any science.

The Symbol

"It is impossible to perceive directly the true which is identical with the divine. We can see it only in its reflection, in similes, in symbols, in individual and related phenomena." In the last resort, mental activity is nothing but the positing

of symbols for objects, operating and reckoning with those symbols instead of with the objects themselves. Portraying the flowing reality in a system of sharply coined symbols, we accomplish mastery of reality in art, science, and technology. In the words of *Faust,* "What in wavering apparition gleams,/I fix in its place with thoughts that stand forever!"

The notion of "symbol," often reappearing in the writings of Goethe, corresponds to the conception of modern epistemology about the function of thinking. It answers that old problem of the meaning of universals and laws of nature which was left open in our former discussion. It is the triumph of the man-created world of symbols that, according to the classic sentence of Heinrich Hertz, the consequences of the images correspond to the images of the consequences, thus making it possible to calculate future events, to predict and in this way to control them.

But Goethe knew something else which modern science, proud of its achievements, is reluctant to admit. We catch the flux of reality in a system of fixed and separating symbols. This enables us to control them in thought and practice. However, any symbol represents one side of reality; it *is not* reality and does not exhaust it. Heraclitus knew this when he called the world a unity of contrasts. Nicholas of Cusa knew it too when stating his doctrine of the *coincidentia oppositorum,* and again Makaria, in Wilhelm Meister's *Years of Travel,* tells the same story when translating from Pseudo-Hippocrates: "Everything is similar, everything is dissimilar, everything useful and detrimental, speaking and mute, rational and irrational. Whatever is said about individual things is often contradictory." Goethe speaks of "polarity" which was one of his favorite terms. We need not inquire here how the basic Heraclitean idea was active in dialectics from Plotinos to Hegel, and finally made a somersault from Hegel's idealism to dialectic materialism.

In any way, Goethe himself is a *"coincidentia oppositorum,"* and it is precisely for that reason that we consider him a most comprehensive expression of humanity. In his work we find next to the most tender lyrics of German language, the obscenities of the *Paralipomena to Faust,* next to the classical *Iphigenia* the robust *Goetz,* next to the poet roaming in the world of sentiments the keen observer of nature and scientist. Far be it from us to attempt to reduce Goethe's personality to a single formula. It is enough if we can grasp from him what we might use, and if our picture reflects only one facet of his being.

Behind Goethe the morphologist is the philosopher of dynamics, behind the dynamic philosopher, the mystic. All life stems from contradictions.

"What wants the needle pointing North?
It never can find itself.
Final rest can only be felt,
As soon as pole touches pole.
Thanketh God therefore, Ye sons of time
That he has set at variance for ever the poles!"
(*Gott, Gemuet und Welt*).

The resolution of the opposites is beyond time, where the eternal "Now," as the mystics have called it, replaces the stream of events:

"Don't tell it to anybody, only the sages,
Because the crowd will mock:
I want to praise the living,
Craving for flaming death (*Selige Sehnsucht*).
"And all the hurry, all the struggle
Is rest eternal in the Lord" (*Zahme Xenien*).

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. . . The philosophy of symbolic forms starts from the presupposition that, if there is any definition of the nature or "essence" of man, this definition can only be understood as a functional one, not a substantial one. We cannot define man by any inherent principle which constitutes his metaphysical essence — nor can we define him by any inborn faculty or instinct that may be ascertained by empirical observation. Man's outstanding characteristic, his distinguishing mark, is not his metaphysical or physical nature — but his work. It is this work, it is the system of human activities, which defines and determines the circle of "humanity." Language, myth, religion, art, science, history are the constituents, the various sectors of this circle. A "philosophy of man" would therefore be a philosophy which would give us insight into the fundamental structure of each of these human activities, and which at the same time would enable us to understand them as an organic whole. Language, art, myth, religion are no isolated, random creations. They are held together by a common bond. . . . It is the basic function of speech, of myth, of art, of religion that we must seek far behind their innumerable shapes and utterances, and that in the last analysis we must attempt to trace back to a common origin. — E. Cassirer, *An Essay On Man* (New Haven, 1944).

THE SOCIAL IMPLICATIONS OF SCIENCE

Howard L. Parsons

University of Tennessee

PART II

IV

The central fact of biology is the attempt of one organism to observe and understand another organism. A physicist observes an organism (atom or molecule) but in so doing he deliberately neglects as many resemblances as he can. For after all *he* is the controlling member in the relation, *he* is the one who will introduce and vary the variables, *he* is the creature of novelty seeking to demonstrate the monotony of the sub-human levels. True, the main characteristics of atoms seem to be endurance, mass effects, qualitative sameness. But the physicist *abstracts* in order to achieve what he sets out to achieve. And he achieves clarity only as he neglects the electronic cloud, certainty as he forgets the Heisenberg principle, coherence as he isolates quanta from relativity, uniformity as he suppresses diversity, and so on.

But the biologist is a different kind of creature. He aims to understand those things in the universe which more plainly resemble himself. (The temperamental differences between biologists and psychologists is an interesting topic for study.) He wants to understand the processes of life in which he himself is an active participant. His attitudes are sympathy (emotional receptivity), sensitivity, responsiveness, loyalty to the perception of what is, alertness to what might be, respect for differences and unities, attention to details, affection for form, patience before unfolding, delight in diversity. Yet these are the attitudes of every scientist. But they are supremely exemplified in the biologist — and by the psychologist, if he has not fallen into the fatal error of cravenly imitating the 19th century physicist. These are the attitudes of the great scientist in every field, for through them men grasp the essential character of events.

Such attitudes can be summed up in the one word "openness." The biologist is open to life because he knows, often from his own life, that while life is recurrence and regularity, it is also variation and novelty, unexpectedness and surprise; and that to be closed is to prevent the newly evolved fact of outer nature from evolving in one's own nature; and that to miss that variation is to miss the whole point of life.

Openness spells the difference between a great specialist and a pedestrian one. The open specialist explores every implication of his specialty, pursuing it to ultimate conclusions. He probes to the foundations of things, making clear to himself how the particulars of his field illustrate universal principles. Thereby not only are the details of his own field elucidated but a light is shed over other, remote fields. But the narrow specialist is content to remain within the prescribed bounds of his field. What he does is done by dint of strict discipline, devoid of imagination and creative daring. But science progresses only as the creativity of nature emerges in the minds of men and is there transformed for enjoyment, understanding, and control. Science then becomes an extension and a favored offspring of creativity in the world.

To read the book of nature, as Bacon put it, is to allow nature to speak. And as in every adequate communication there must be in science receptivity on the one hand and freedom of expression on the other. The observer must bring "a heart that watches and receives." And as every biologist *in vivo* knows, the subject studied must be free to express his full nature. The same principle holds with greater force in psychology, where one human being observes another and where the interaction is a crucial determinant in the investigation. This is strikingly apparent in the observation of mental patients; for whether the therapist can communicate his attitude of sympathetic understanding, enter into the feelings of the patient, and interact with him in a permissive and reassuring way — this makes all the difference in the world as to whether the therapist will acquire the data and develop the trust necessary for cure.

In any case one is required to respect the character of the organism one is dealing with, if truth is what is desired. One must leave paramecia in water if one wants to observe them in their active state. If one wishes to observe the normal development of young mammals, one must, in the absence of their mother, assume the role of a mother toward them. If chimpanzees are under study, one must act with consistency, consideration, and kindness.

This healthy respect for reality, which Freud called the reality principle characteristic of mature behavior, is not peculiar to the scientist, who in his search for truth strives to keep his personal distortions out of his picture of reality, however unpleasant that picture may be. The respect for reality dominates every adaptable organism. Indeed, organisms are in a sense born with this respect, for at birth they are enmeshed in orderly processes which define and delimit what they are and what they may become. There is a sense of other bodies standing over against one's own body, bodies which are friendly or hostile, bodies which communicate their import, bodies upon which one depends indispensably for life. The organism strives to secure satisfying relations with such bodies. The scientist, by exploiting his tools for

openness (the hand, the senses, the cerebrum), simply expresses supremely this striving in all organisms.

Openness is receptivity to variation. In a nature where change is legion, variation becomes an instrument for variable and enjoyable survival. It is not mere survival that is effected; endurance serves mere survival, and it has been perfected by the atoms, most of which are stable and inert, complacently enduring through the eons of the world, content with dumb immortality under the stars.

We may speculate that among the many complex molecular forms generated in the early marine orgy of atomic promiscuity, those molecules survived which best maintained their unstable condition of complexity — doing so by a process of growth and eventual fission, made possible by their ability to absorb various substances in their environment. According to Gamow, these primitive molecules ("coazervates"), unions of colloidal solutions possessing opposite charges, evolved by a process of selection in living forms.[20] Endurance was thereby maintained, but at a more complex, variegated, and precarious level.

Further, those complex carbohydrate molecules were favored in the struggle for existence not simply because they obtained food but because as unique unions of parts (colloidal solutions) each part was saved from the uncertainties of individual struggle, and from the simplicity of isolation. There was integration, issuing in the endurance of the novel integration; and the complex endurance in turn displayed the variation of successive generations. Societies merged to form more complex and sensitive societies.

The emergence of this new type of organism (or society) marks an advance over the symbiosis of proton and electron. It exhibits variation, and incipient enjoyment. The evolution of this variation is dim, but definite. First, there is the primitive rhythm expressible in the wave motions of the smallest known particles. Then there is the rhythm of a single atom, and of a single molecule, and of groups of molecules, and of a stabilized water colloid. Then there is the gradient growth of a coazervate, and at last the superb rhythm of fission in the first protoplasms — later extended into the rhythms of spore and sex reproduction, and insect metamorphoses.

In a world of stability and permanence, variation is ordinarily unnecessary for survival. A dull universe sustains dull organisms, and a simple universe puts a premium on simpletons. Only the hard survive under hard conditions. In the early, relatively stable period of the earth's evolution, the hardier, heavier elements originated — later, the lighter and more complex rocks. Then came the warm rains, and the emergence of life.

[20]Gamow, G., *Biography of the Earth*. New York: New American Library, 1948, pp. 155-161.

Such changes, we may infer, were slow and orderly, and survival was comparatively easy. But as changes in the total biosphere occurred they combined to produce an environment that favored the variable species. For in a universe with a variable environment variable behavior operates as favorable to survival.

Variation also makes for enjoyment. The adaptability of protoplasm is its sensitivity and responsiveness. But these are gradient activity, instruments of variation and hence, in a variable world, instruments of survival. In a changing world, those organisms survive which sense the changes and adjust accordingly. Sentience is therefore favored; it prepares the organism, as Cannon says, for "fight or flight." Feeling is evoked primarily in conflict, and feeling is vivid awareness, the precondition of enjoyment. In the higher organisms sentience is released from its survival function, and cultivated for its own sake — as in the flight of birds, the play of porpoises, and the symbolic activities of men, like art and mathematics.

Variation rises to fullest expression in the mentality of man, which is the source of his freedom. Science is that mentality working on the side of abstract structure, though never devoid of some esthetic content. Science is an instrument of survival and of enjoyment. By means of its laws it orients men to those invariant and reliable features of the universe on which men depend for life. And in its method of exploration, experimentation, tentativity, and flexibility, it furnishes a tool for adjustment to change. The scientific will inherit the earth, for they possess the finest devices for cooperating with and recreating that earth. The scientific method is a way in which one organism responds sensitively to another, feeling the novelty of quality and pattern, integrating what is felt with the fund of previous experience, and envisaging new patterns of possibility. The "lower" animals are fellow scientists with us, though somewhat inferior. In its most concrete operation science is a prime example of that innovating-integrating activity which we have called creativity. There is the emerging into awareness of new perspectives; the integrating of these perspectives into a new hypothesis; the differentiation of this hypothesis into its details of implication; and the integrating of these details in their total pattern with observed fact and established theory. This creative process is not merely symbolic; it is neural-muscular-glandular-etc., in a word, *organismic transformation*.

Of course science in its highest reaches is mathematical. It thereby removes particularities in observer and observed and attains generality of pattern. But the formulation of a mathematical hypothesis, the elaboration of its consequences, and the correlation of tested data are equivalent to the occupation troops once the sector has been

taken in an emotional drive. It is sensitivity, the capacity to intuit the underlying patterns of interconnection in the world, which is the foremost activity of the scientist. Otherwise, all his coefficients of correlation are but as sounding brass, and tinkling cymbals. The great scientist is gifted with this preternatural discernment. He is also equipped with a stubborn and painstaking determination to clarify and test his intuition, and he has the symbolic apparatus whereby to do so. Finally, he is a creature of social relations which nurture his sensitivity, and reinforce his determination, and provide him with symbols for expression. Thus creativity works through his social relations to engender novel and general perspectives which penetrate to the heart of things.

V

But how shall these perspectives of the scientist be used? It is not enough for creativity to work in nature and in the mind of man. When creativity rises to expression in man it is both released from the limitations of the strictly physical and biological orders and endangered by its new freedom at the higher level. As Engels says:

> ". . . for the first time, man, in a certain sense, is finally marked off from the rest of the animal kingdom, and emerges from mere animal conditions of existence into really human ones. The whole sphere of the conditions of life which environ man, and which have hitherto ruled man, now comes under the dominion and control of man, who for the first time becomes the real, conscious lord of nature, because he has now become the master of his own social organization."[21]

But to be a master does not always mean mastery. The scientific method is not an infallible instrument of survival. The fundamental question is: Is the scientific method used so as to further release creativity? A man may use that method to determine how to exterminate six million Jews, or 200 million Russians; or he may use it to determine how the institutions of human society might be revised so as to allow two billion human beings to live creatively and joyfully.

Some of the atomic scientists have sensed a fatal contradiction between the wholesale destruction of scientific warfare and the spirit of science. They realize that science is not an end in itself, nor an isolated activity; that it requires freedom from society, and in turn owes that society an obligation; that as a fruit of life it must perforce be concerned about the roots of life; that science is the servant of man and the carrier of creativity; that only by serving creativity can it escape that isolationism, dogmatism, irresponsibility, and self-defeating procedure of which it has been accused.

[21]Engels, F., *Socialism, Utopian and Scientific.* New York: International Publishers, 1935, p. 72.

As his task is thus understood, the scientist confronts three questions: What is the nature of creativity in the world; what is the ultimate source of good? What are those physical, biological, social, and mental conditions necessary for its release in the world? What needs to be done, here and now, by me and others, to establish those conditions?

If the scientist replies that his primary loyalty is to facts, I answer that that very loyalty is a preference for reality as over against illusion. If he says he sticks to the scientific method, I answer that that very method is the work of creativity. If he holds that he abides by reality, I answer that the fundamental nature of reality is social, and this social character is generated by creativity. Science itself is a superbly cooperative enterprise, "based on the recognition that one belongs to a community; but a community which requires that one should do one's damnedest to pick holes in its beliefs."[22]

If we survey the history of the universe we may see creativity working slowly, patiently, and tenaciously against the forces of isolation, dissolution, and death, to rear progressively higher structures of value, with refined sentience, widened variation, and keener mentality. Creativity is not the only power at work. There is the massive inertia of molar matter, and entropy, assymmetry, deformity, and disease; there is the persistence of unimaginative simplicity in biological organisms, and the unremitting struggle for existence. There are fears, hostilities, prejudices, wars, and all manner of resistances against growing truth. But through it all we may perceive the gradual triumph of progressive mutuality, sending forth threads of novelty and weaving them into richer patterns of synthesis.

The story of creativity is that of a series of critical struggles, achievements, and plateaus. There is first advance, then arrest; first a strong unity, mutually beneficial to the united parts, then a loose unity paving the way for stronger unity in time. There is the unity of atoms and molecules; then colloids, preceding the unity of unicellular organisms; then clusters, preceding the unity of complex organisms; then sexual differentiation of cells, preceding the unity of the family; then those aggregations of families preceding a true functional society, where the good of each contributes to all, and where the parts determine the whole, and the whole the parts.

Civilization is now struggling at that juncture between tribal organization of families and a genuine world society. The highest loyalty of most men is to the nation; but some envisage a world society united by bonds of mutual sympathy and understanding. In every similar struggle in the past, the newer forces, the smaller group with

[22]Waddington, C., *The Scientific Attitude.* (2nd ed.) West Drayton, England: Penguin Books, 1948, p. 112.

the larger social vision, have eventually triumphed.[23] It is probably true that good causes have failed, of which we have no record. The prophets of the Lord, as well as the false prophets, were stoned to death. But in the long span of history, mentality, imagination, science have been on the side of sympathy, mutual aid, and brotherhood. Reason has led men to come to terms with reality; and reality has disclosed itself as dynamically social, as inexhaustibly creative. Reason itself is a social process, linking man with man, and man with the reality of nature, in cooperative ties.

That upward striving endures enormous tolls. Great individuals, communities, and civilizations are lost; and those that might have lived and marched in glory are never born. What is achieved is destroyed, what is possible miscarries for want of vision, energy, proper habits, sound theory or technique. Also there have been retrogressions. A totalitarian world order along Nazi lines is possible. Extermination of all life is conceivable. Viewing such possibilities the scientist is apt to question if there be *any* social implications of science. For already the seamless web of nature is disrupted, and the whole planet is plundered. The binding ties of men, as perceived by Confucius, are dissolving. Good will among the nations disappears. And men may now arrange alliances with the demonic, pathic powers in the universe, the lethal bacteria and the unleashed atoms, to destroy not only brotherhood but the very foundations of the biological and physical universe.

Science in the service of creativity can save us for survival and for the more abundant life. All human progress now must be mental; for us the guiding factor in evolution is mind. But a more important factor must guide that mind, since it creates and transforms mind. That is creativity, which mind may perceive, understand, and serve.

Progress is also social. Scientists cooperate in the laboratory, across thousands of miles, and thousands of years. What hinders them from making a concerted assault on the pathologies of our over-all social system? (1) That social system itself, in which we learn that unions are beneath the white-collar workers, that it is best to "look out for number one," that we must preserve the freedom of the individual scientist, that it is vocational and social suicide to stick one's individual neck out, that business is business and science is science and never the twain shall meet, that the scientist forfeits his right as a citizen when he goes to work for the government, that science is one thing and value another, and so on. (2) Our own lack of brains and guts, of wisdom and courage. We have had enough of science; we now need *scientists,* impelled by a passion to know. That passion itself is progress.

[23]Needham, J., *Science and Society,* 1946, 3, 229.

Immersed in technology and specialization, we forget that the generic, historic aim of science is wisdom. The current philosophy in training young scientists is to give the customers what they want — namely, the tricks of a trade, the means of making money, the power for prestige, the tools of private acquisitiveness. Social service is neither sought nor taught. But technicians are a glut on the market, a social curse. They not only run our society (lawyers in Congress, soldiers and business men in executive positions) but they think they are practical and wise to boot. But observe where the "practical" men have led us. The only way to produce wise, socially conscientious leaders is to produce wise men and women in greater abundance. As scientists determine which students pass their courses, which ideas are assessed as important, they determine the character of future leaders and guide the course of society. To put a premium on specialism is to invite death for the race.

An over-supply of technicians is a curse for science itself. There is a need for experimental design, devices for testing, painstaking observation and calculation. But all of these are primarily outworkings of a creative idea, sprung in the imagination of a wise man. Archimedes discovered specific gravity as he lay in his bath, and Descartes invented analytic geometry as he lay in bed. Of course one might argue that they were both experimenting. Moreover, technique is indispensable for advance; and a great scientific achievement is the marriage of imagination with technique. But the exclusive concern with details, with disconnected problems, with immediate utilities — as over against the concern with germinal hypotheses, with bold speculations, and with the broad social implications of science — is deadly. The latter require courage and wisdom. It is easier and more lucrative to do applied research for DuPont than to do pure research in a university.

In ancient times scientists and other professionals formed "unprogressive castes"; but now "professionalism has been mated with progress." [24] The economics of ancient cultures required scientists to be hirelings of the ruling class, but today history requires them to be responsible, creative leaders in a society which cries out for reform.

The progress of human society parallels scientific progress. The latter is marked by progressive leaps of new insights. It is a sequence of a few great ideas, interspersed by corollaries, elaborations, widened applications, and finally sterile routine. At length another great idea is broken loose, in the mind of one man or more often in the minds of a group of men, and progress is swept to new levels. But many scientists today are not thinkers; they are slaves to the tyrannous laboratory method or to the industry where they are

[24]Whitehead, A., op. cit., p. 205.

employed. To be sure, scientists do not consider themselves slaves; but neither did the Nazi scientists.

Science is still in its youth. For years the mass of scientists have shown all the earmarks of advanced adolescence, as seen, say, in college youth. They have sought facts indiscriminately, and voraciously. They have demanded the luxuries of living in society, but have resented any responsibilities toward that society. They have proceeded by the adolescent code of live and let live. They have scorned emotion. They have arrived at the callow conclusion that all values are relative. They have vacillated between faith in automatic, linear progress, and an existentialistic self-indulgent cynicism toward mankind.

But the next stage in science will be that of maturity. During this period we may look for scientists to take an active part as leaders in improving the human world. Science will become more social, in theory and practice, and society more scientific. Scientists will apply the principles they have learned for the enjoyable survival of mankind, and in so doing they must inevitably discover and apply the principle of sociality, of creativity.

Standing in the way of creative advance are inert institutions, frightened men, and oppressive leaders, all intolerant of change, all clutching at outmoded social orders, enemies of the new and creative. Still, when we scan the history of our planet, from its unpromising beginning to the present day, we may be heartened. There has always been struggle, and antagonism. There has been infinite loss, both of opportunity and achieved value. There has been the perpetual perishing of life striving to endure, the fading of vivid enjoyments, and the passing away of transient dreams of greatness. There has been love dissipated by violence, inspiration relapsed into torpor, fresh methods hardened into habit. High orders of value, like beauty, have dissolved. Noble causes have gone awry. Truth has been ignored. Suffering has undermined the strong-hearted. Sympathy and love have died in a world of indifference and depredation.

But on the other side there have been sensitive creatures, with fellow-feeling, and mutual helpfulness, and imagination, whereby there is victory over the grave of sheer endurance. Novelty there has been, the spirit of variation and adventure, and the gentle knitting work of integration. There have been those who gave up their lives that others might live; martyrs in the cause of truth; wise men driving back the walls of outer darkness; saints, making the vision of love incarnate. Undaunted and undespairing, those who died devotedly, often blindly, for values and purposes deeper and more enduring than themselves or their eras — all show forth the slow, patient push and lure of creativity, silently overcoming the drag and derangement of things, progressively harmonizing the diverse elements of the world into ever finer and richer forms of enjoyment.

CULTURAL EDUCATION FOR PRE-MEDICAL STUDENTS

In his annual report to Dwight D. Eisenhower, president, Columbia University, Willard C. Rappleye, dean of the Faculty of Medicine, has recommended the abolition of "premedical education." The college preparation for medical, dental, and public-health fields should not be professional in character but should provide as broad a cultural education as can be given in the institution attended by the students. This education should be "a preparation not for medicine or dentistry or public health, but for life."

The selection of students for professional education should be not so much on the basis of grades or subjects as for character, personality, intelligence, ability, industry, general culture, resourcefulness, maturity, and evidence of a grasp of principles underlying the sciences upon which medical study depends.

"Our professions will occupy their proper place in modern society to the extent that they provide leadership and trained personnel" with the essential knowledge to solve the national health problem.

Referring to the problem of adequate health services and the responsibilities of the medical profession Dean Rappleye writes:

"It is our responsibility to create an environment for medical and health services which will provide opportunities for the very expression of individualism, which has made medicine and its allied health sciences so conspicuous in the improvement of the welfare of man."

He pointed out further that the organization and administration of health and medical services "must of necessity avoid the proposals of the extremists who, on the one hand, advocate complete governmental control and management, or, on the other hand, are equally vigorous in defending vested interests and the status quo. It is often difficult to steer a course in the middle of the road, particularly because that requires a high order of judgment and courage."

Progress must be made by evolution, but it also must be progress, Dr. Rappleye concluded.

—*School and Society*, Vol. 72, No. 1860, p. 108

TOWARD CREATIVE THINKING

Loring M. Thompson

Champlain College

Must creative thinking be reserved for the Einsteins and Pasteurs, who are at the outposts of science? Can creative thinking, as well as absorption of facts and training in vocational techniques, be made a part of the general education?

It is the thesis of this paper (a) that creative thinking is highly desirable for both individual happiness and collective social welfare and (b) that educational methodology can do much to encourage creative thinking by students and by people generally.

Modern industry with its specialization undoubtedly achieves outstanding material productivity, but not without dangerously threatening the individual citizen with loss of his individuality and creativeness amid the uniformity of the assembly line. Psychologists have found that people need opportunities to express their individuality and creativity in order to find happiness and satisfaction in living. Observations of children and industrial workers indicate that both personal satisfaction and material productivity will increase when persons are properly led to their own solutions of every-day problems. In spite of the pressures for uniformity and centralization, it appears worth-while to maintain the individuality of each citizen, to give him the opportunity to think for himself and thereby strengthen society with the contributions of a large number of alert citizens.

Although modern science admits that spontaneity and insight are essential for the formulation of new theories, modern education tends toward the memory of facts and the practice of stereotyped techniques rather than the cultivation of spontaneity. Without overlooking the importance of facts and established procedures, it is also important for us to develop fresh ideas which may contribute to the solution of urgent problems confronting the world today. Traditional scholarship assembles and classifies facts from the past and present. Students assemble a great mass of specific information and become conversant with existing theories and their justification. Presumably this is all a very important background for scientific work which must be included in the educational process. But how can we cultivate spontaneous and original thinking also?

There are two procedures in education and research which would do much to develop the facility of spontaneous and original thinking. These are listed below and described in greater detail in the paragraphs that follow:

(a) Individual re-thinking of existing ideas.

In the classroom, give students the opportunity to formulate ideas, relationships, and theories for themselves before explaining solutions advanced by others.

(b) Preliminary theories prior to scholarship.

Add to the steps in research procedure a preliminary development of individual theories prior to detailed, scholarly analysis of existing pertinent theories.

Individual Re-Thinking of Existing Ideas

To make the classroom a center for creative thinking requires only the use of instructors with the ability to *lead* reasonably small classes rather than to lecture from prepared notes. The procedure of intellectual leadership is as old as Socrates, who recognized that students learn what they themselves think through for themselves. In this way, the student is brought into the educational process as an active participant rather than a passive absorber in a process in which the instructor's notes become the student's without going through the heads of either.

The instructor's first step is to outline the problem or facts for analysis, then challenge the alertness of the students to make intellectual contributions. Subsequent comparisons with conclusions of others may be used to sharpen the students' powers of discrimination, understanding, and intellectual honesty and flexibility.

As an example of this procedure, the teacher of mathematics may guide the class to suggesting simple theorums and their proofs rather than plunging into explanations of proofs whose reproduction will be required on examinations. The teacher of economics may present economics facts that point to generalizations or the need for additional clarifying facts. In the study of business management, it is perhaps easier to assemble typical business situations whose solutions give a practical aspect to the classroom. Regardless of the particular subject, however, the leadership of the teacher can encourage students to draw tentative conclusions from available facts, then compare these solutions with those advanced by others and with additional facts.

In a properly conducted classroom, the opportunity for original thinking will not be detrimental to the absorption of knowledge. Students will remember ideas which first came to them, even partially, through their own insight. While it might be objected that the procedure suggested is too time-consuming to permit the absorption of the ever increasing background of knowledge which is needed in all fields, a more enlightened viewpoint admits the inability of the human mind

to remember facts and relies on the ability to summarize facts and to find detailed pertinent facts when they are needed. Do we want to develop students into walking encyclopedias or into thinking persons who habitually use a library efficiently or observe for themselves?

Preliminary Theories Prior to Scholarship

Students preparing research papers are generally advised to review the literature of the field as the next step after a topic has been selected. Certainly it is intelligent to consider the research and theories of others, thereby avoiding possible duplication of effort and applying the efficiency of the division of labor in the intellectual world as well as in the factory. At the same time, too much concentration on existing knowledge will never lead to any new contributions to the knowledge. Even though a finished paper would be difficult to defend if the writer were ignorant of pertinent existing knowledge and scholarship, this requirement should not eclipse all freshness and spontaneity of approach. By bringing in spontaneous thinking prior to the detailed research, the stage is set for its continuation and fruition in fresh and sound conclusions at the end of the project.

The encouragement of spontaneity described above does not in any way eliminate or minimize the steps generally included in various statements of scientific method and procedure. The importance of facts, scholarship, and existing literature is in no way depreciated. On the contrary, they are emphasized because of their importance in the evaluation of tentative theories.

General Practice of Scientific Method

In a learning and research process which includes original thinking by each individual, the scientific method becomes more widespread through its practice *in its entirety* by greater numbers of people. The division of labor is not carried to absurd and mentally debilitating extremes. Creative thinking is not reserved for a few prominent scientists, with others blindly collecting data or absorbing the conclusions of the scholars without critical analysis. On the contrary, a scientific attitude is learned by living it, by continually applying it in the process of education, of research, and of day-to-day living. Furthermore, this practice of the scientific method includes the practice of creative thinking as well as the comparison of theories.

To summarize in general terms, the healthy and scientific approach to a situation is indicated by the following steps:

(a) assembly of facts which are most obviously pertinent;

(b) formulation of one's own best spontaneous solution;

(c) review and comparison of solutions advocated by others;

(d) assembly of additional facts which now appear to be pertinent;

(e) synthesis of own ideas with those of others;

(f) critical comparison of synthesis with facts; and

(g) repetition of above steps as necessary.

A CORE OF GENERAL EDUCATION FOR ENGINEERING CURRICULA

Donald G. Stillman

Clarkson College of Technology

(Presented at the Humanistic-Social Division Summer School preceding the annual meeting of the A. S. E. E. at East Lansing, Michigan, June 21, 1951).

This is one of a series of news reports on major and notable examples of modern college practice. The editor of this department, A. Gordon Melvin, City College, New York, is interested in receiving similar reports and accounts of work in other colleges and universities. These should be mailed to him in care of MAIN CURRENTS.

Education in the United States faces two tremendous challenges today. They rise from two sets of circumstances unique in history. The first of these is that never before has a nation had so high a percentage of its population pursuing higher education, and never before has a nation invested so much of its income, both private and public, in education at every level. From these circumstances comes the challenge: Are we as a nation becoming better able to solve the problems we face? Are we that much more capable of surviving? Are we developing a kind of society which is more worthy of survival? If we are to get a fair return for our investment in time and money, what kind of education can meet this challenge in a better way?

The second set of circumstances is the prodigious advance of knowledge in the last fifty or seventy-five years. New information and verified facts and world-shaking discoveries and theories are piling up at an ever increasing rate, so that it has become necessary to specialize more and more in our training, in our research, and in our education. Here is our second challenge: With

all our need for specialization, are we to neglect seeing the relation of the specialized area to the whole, and to omit an understanding of the relation of the individual to other people and to society as a whole? Man as specialist and man as citizen-and-family-member must not be split in our thinking or in our education, for they are two faces of the same coin. What kind of education can meet *this* challenge in a better way?

Both of these challenges may be met by the concept we call general education. It is variously labeled "core curriculum" or "basic college" or "liberal studies" or "humanistic-social stem," and it aims at giving the student some knowledge of our common heritage and institutions, our social, political, and moral responsibilities, the values and ideals of our society; it aims to teach the student to read critically, reason objectively, and become mature in mind and emotions; it aims to help the individual to a fuller, more satisfactory life. General education, by whatever label it may be known, is that part which should be common to each person's education, whatever the specialty.

Some professions, such as medicine and law, meet this need by requiring a "liberal education" before the specialized work is done. Engineering is finding its way toward better professional training by several means: the five-year curriculum, the co-operative five-year plans whereby a student gets two degrees, and the incorporation, into the regular engineering curriculum, of non-technical courses which contribute to the student's growth as an individual and as a responsible and constructive citizen. But however the program is to be administered, there are certain goals and needs. It is the purpose of this paper to examine the aims, to outline some of the problems, and to propose several solutions to the problems involved in establishing or improving the core of general education for engineering curricula. I shall try to discuss these in terms which can apply to different college situations, in terms of goals and areas of knowledge rather than specific courses, but suggesting particular ways of meeting the requirements. Before concluding, I should like to indicate the specific solutions which we are working out in the program at Clarkson.

I. *The Goal in Terms of Knowledge and Skills*

In setting forth the goals, I think it would be difficult to improve on the statement in the Hammond Report[1] on the objectives of the humanistic-social division:

1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose towards these ends.
3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.
4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence on civilization.
5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with public welfare, and to a sound professional attitude.
6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.

If I were to supplement these objectives, it would be to provide the student with concepts of physical, emotional and mental maturity, and with an understanding of the role of mental health in both his professional and his personal life.

These goals are difficult enough to meet in a full four year curriculum. The attempt to meet them in the restricted time set aside for them in the engineering curricula is enough to challenge the ingenuity and wisdom of the best minds available.

II. *The Goal in Terms of Areas of Study*

If we think of the goals in terms of areas to which the student should be introduced, we may group all subjects under the four general headings of communication, humanities, social studies, and natural sciences. Communication includes the study of language as a tool in reading and writing, speaking and listening, and may include artistic and mathematical communication, though these are usually placed elsewhere. This heading should include rhetoric, logic, and propaganda analysis. The humanities include literature, art, philosophy, religion, and some aspects of history. Social studies are comprised of such subjects as history, sociology, economics, government, politics. Psychology is frequently grouped here, but certain aspects of it may be placed in the following classification. The natural sciences are physics, chemistry, geology and astronomy, biology (including physical and mental hygiene), and mathematics, which is most closely associated with this group though it may be assigned elsewhere. Another class may be added which might properly be called "applied science" and would include courses in technology and the professional application of scientific knowledge, such as those given in preparing students to be physicians or engineers.

Which of the areas outlined are covered in the specialized training of the engineer? They are mathematics and the natural sciences except for biology. What areas are needed to supplement the technical part of the engineer's education? They

[1]Report of Committee on Engineering Education After the War, printed in the *Journal of Engineering Education*, Vol. 34, No. 9, May, 1944. The objectives cited are from page 593.

are the four general areas: communication, humanities, social studies, and life sciences (in which I would include psychology and mental health).

Now it is perfectly clear that this is a big order. It also seems clear that the adding of a course here and there from the liberal arts college is not going to meet the goals which have been set up. It would seem further that there is a need for integrating and inter-relating areas and for breaking down the separations between traditional departments if we are to use the limited time at our disposal to the best advantage. This means new courses designed to meet our needs. It involves solution of three groups of problems which we will consider next: problems of core courses, the problem of departments to carry the core curriculum, and the problem of getting staff members for an integrated program in general education for engineers.

III. *The Problems of Core Courses*

Before a program can be established, a certain quantity of credit-hours must be made available. This is a difficult task and must be done by persons other than the teachers involved in the general education program; in other words, it must be done by those in charge of the engineering program. It can be done by a committee of the faculty, by a committee of faculty and administration (as, for example, the dean and the curriculum committee), or by the administrative officers. As for the proportion of time which could be considered a minimum for working out any satisfactory kind of program, I refer again to the report of the Hammond Committee, which recognizes that the objectives "can be achieved only through a *designed sequence* of courses extending throughout the four undergraduate years and requiring a minimum of approximately 20 percent of the student's educational time. This allotment should be at least equivalent to one three-hour course extending throughout the curriculum, and on the average somewhat more" (From page 594).

We do not want to miss sight of extra-curricular encouragement of the student's development; but for any sound program, a specific allotment of credit-hours is primary.

Twenty percent of a four year engineering program would be about 30 semester credit-hours or about 45 credit-hours under the quarter system. A five year program may have more, but we must recognize that some schools for the present must try to build a program with fewer hours. One engineering college allots 25 percent of its curriculum to general education, even carrying the proportion into its first year of graduate work.

With the time we have, where shall we begin? Most colleges agree that communication skills are fundamental to the rest of the program and allot to them three hours throughout the first year, though often enough these skills are combined with subject matter courses. In any case, it is imperative that these skills be introduced early and be given continued exercise through all four years if the student is to gain the desired proficiency. It is particularly helpful if teachers on the technical staff co-operate by demanding a decent standard of expression on all reports and papers, and by deducting from the student's grade for poor English.

Beyond the fairly common freshman communications requirement, there are three types of program which can be set up. The first is to allow the student a wide selection. This has been done where the courses are given outside the engineering school in the liberal arts college. The results are sometimes good, but such a program is apt to be haphazard, encourage election of "snap courses," and come nowhere near meeting the needs of general education. The second type of program is a set of required courses. This is especially appropriate when the number of credit-hours is below the recommendation. The courses can be effective if they are designed to integrate subjects in related areas as they fit the needs of engineering students. The problem of this plan is to get the superior teachers required for integrated courses so that the material covered will not be taught superficially. The third possible program is one in which some courses are required and some are elected by the students. Such a program is generally desirable if the electives are alternatives within restricted areas. It is desirable also to give the student opportunity to study at least one subject more thoroughly than is possible in the required courses. In most programs of this kind, there will be more required than elective courses.

The content of the specific courses in any of these programs will depend on the goals agreed upon and on the experience of the persons designing and teaching the courses. What a particular college does will depend in part on the department or departments which will do the teaching.

IV. *The Problem of Departments to Carry the Core Curriculum*

Successful programs may be set up under different departmental arrangements. The best organization will vary with the particular college or university. If the present program is not satisfactory, it may be that a different departmental organization should be considered.

There are three general solutions to the problem of departments to carry the core curriculum.

A. The work in general education may be given by the liberal arts faculty, outside the engineering school. This is satisfactory if the courses fit the goals and if the teachers involved have a specific interest in teaching engineering students. There are, however, some difficulties here: With courses taken in different subjects, there is likely to be a minimum of inter-relation between areas;

the engineering students may be considered a side line and not be given the best or even the average teachers; and the sequence of courses under this system is usually more difficult to arrange in a satisfactory manner. Nevertheless, with proper planning and administrative support, such an arrangement can produce a program consistent with our goals.

B. The work in general education may be given by several departments within the engineering college. These are usually designated English and Literature, History and Social Studies, Economics, and so on. This organization works well frequently, especially in the larger engineering colleges. The average sized and smaller engineering colleges, however, are sometimes restricted to just an English department, or just English and History or Economics. The danger here is that they may be narrowly departmental and teach just their specialized courses. But with the right personnel and with interdepartmental co-operation and planning, the goals may be met quite satisfactorily.

C. The work in general education may be given by an integrated department which is organized within the engineering college or which is a separate division of the university. Within the college these departments are given such titles as Humanities or Liberal Studies; separate divisions of the university are designated Basic College, College of General Education, or General College. This plan for handling the core curriculum is not always possible, but the trend seems to be in this direction. Both sets of the goals we have suggested can best be co-ordinated when the core courses are planned and supervised as a unit, and where the areas are interrelated and the teachers are acquainted with the whole basic program. Hence, under the integrated department or basic college plan, the time set aside for the humanistic-social part of the engineer's education can be most effectively used.

V. *The Problem of Staff Members for An Integrated Program*

One of the primary problems in establishing an integrated department or basic college is finding staff members. Such a program requires special talents, training, and interests, and if suitable teachers can be found, they must be offered adequate compensation. It should be expected that salary scales be on a plane equal to that of the technical staff of the engineering college, but such is not always the case. Discrimination against one department will result in a less effective program.

Finding staff members whose knowledge and experience are broad, and who have achieved some distinction in a particular area, is still a difficulty. A few universities give their graduate students encouragement in developing broader implications of their restricted field, but too many keep narrowing the student's interest to the point where he becomes myopic. It is, however, important that the teacher in the basic program have a specialized knowledge of one or two fields. But it is equally important that he know something of all areas, including science. It is also desirable that the teacher have at least the background of the core curriculum which is to be given the student of engineering. Teachers or graduate students who have worked in two fields and are especially interested in integrative programs are likely candidates. Teachers willing to grow in this direction can help themselves and the program by teaching the core subjects in turn. The more the basic courses are the concern of the whole staff, the better the integration will be.

Another problem in securing teachers is that of giving them a chance to work and teach in the field of their special interests. I have tried to solve this by assigning at least one advanced elective course in the area of his specialized training so that he may keep up with the new material in his field and contribute to the program by offering a course which has more concentration than can be the case in the basic courses. With a good pay scale and with an opportunity for teachers to keep up with special interests, the problem of securing a good staff for a program of general education can be met successfully.

There is one other problem which should have at least passing notice, and that is winning the respect and co-operation of the students. It is important to explain to engineering students why they need non-technical subjects for professional reasons as well as for their personal education. Here again it is very helpful to have the active support of teachers of the technical staff. In the last analysis, however, a good staff and a sound program will win the respect of the serious students more quickly than any propagandizing.

VI. *The Liberal Studies Program at Clarkson*

It may be of some interest at this point to present briefly a program in operation. The humanistic-social stem of the engineer's education at Clarkson College of Technology is given by the Department of Liberal Studies. For the program, 29 semester credit-hours have been set aside. These are distributed as follows:

6 hours: *English Communication*. Developing skills in reading, writing, organization, with an introduction to logic, propaganda analysis, and the research paper.

2 hours: *Oral Communication*. Developing confidence in speaking before an audience, practice in organization and diction and in organized group discussion.

6 hours: *Humanities*. Some masterpieces of world literature, analyzed for light on human

values and problems as well as for literary values, and an introduction to the arts through techniques with encouragement to undertake a creative project. Continued practice in writing and speaking is planned in all courses which follow the communication sequence.

6 hours: *Economics and Administration for Engineers.* Introduction to economic theory and practices, and the problems related to engineering.

3 hours: *Foundations of Modern Civilization.* The evolution of western civilization from the Renaissance to the present, its art, thought, science, and social and political institutions. Reading in a contemporary news periodical (*Time* Magazine).

3 hours: *Problems of Modern Civilization.* An analysis of some economic and political problems, social problems, ethical problems, and personal problems, including the concept of mental health and intellectual maturity, fostering the ability to analyze problems objectively on the basis of reliable information and to come to reasoned conclusions. Reading the periodical *The Reporter.*

3 hours: *Liberal Studies Elective* from the following: Advanced Speech, Major English or American Writers, American History, History Seminar (Germany and Russia, or the Far East), Sociology, Psychology, Philosophy, Drama, Contemporary Literature, Art, Music, Advanced Reading Seminar.

These make the 29 hours, but there is need of an additional required course in "Life Sciences" which would introduce the student to biology and psychology and would include the material on mental health and emotional and intellectual maturity. This seems to be the area most neglected in programs. I hope to have material organized for such a course within a year or two.

In teaching these courses in the various areas of study, we try to incorporate the various objectives stated in the Hammond Report, and thus approach both sets of goals as outlined earlier in this paper. All members of the staff have taught the humanities course and most of them the courses in civilization, so that the departmental offerings can be as effectively integrated as possible. Each teacher above the rank of instructor has at least one course among the electives in his special field of interest, and can take advantage of the student's background in the core courses to make effective use of his time and work in the senior elective.

Conclusion

The truth is that *successful* engineers have, for the most part, acquired the characteristics, skills, and interests which have been set up earlier in this paper as our goals. They have received them from family, formal education, friends, natural interest, and experience. If a student comes to the engineering college with these interests, he should be guided and encouraged in their development. If he does not have these interests and skills, they need to be prescribed, for his success in his chosen field depends upon their development, as well as his success as an individual and as a member of society. We must guard against thinking a student is educated when he gets his diploma. Education is a life-time process, and the best we can do is to lay a foundation on which continued growth is possible and probable.

We have come back to the two challenges with which we began. We must continually strive to make our formal education more effective. We must strive to make our society come closer to the ideals which give it its best quality and character. We must give the student the specialized education which our age demands and at the same time prepare him to use all his talents for the public good and the enrichment of his own personal life. A well organized core of general education can go a long way in meeting these vital challenges and responsibilities in the education of the engineer.

Bart J. Bok of the Harvard College Observatory has prepared an article and a pamphlet for UNESCO. Based on the Universal Declaration of Human Rights he proposed a revision of the charter for scientists, which comes very close to the objectives of the SSRS. (See for example the Bulletin of the Atomic Scientists, Vol. 5, p. 217, and the FAS Newsletter of March 1, 1950, p. 3.) This charter defines, among other things, as a duty for every scientist: "to examine searchingly the meaning and purposes of the work that he or she is performing, and when in the employ of others, to inquire into these purposes and to evaluate the moral issues that may be involved; to promote the development of science in the ways most beneficial to all mankind and to exert his or her influence as far as possible to prevent its misuse."

—*SSRS Newsletter*

REVIEWS

Dr. Ordway Tead, author of many books on social, educational, and administrative subjects, for many years Chairman of the Board of Higher Education in New York City and Lecturer in Personnel Administration at Columbia University, has come forth with a book, *The Art of Administration* (McGraw-Hill, New York, 1951) which is described as "the *what, why,* and *how* of administration in relation to leadership, personal power, authority, and coordination in top management."

With the prefatory statement that his purpose is twofold, the author sets out to demonstrate the practical intention "of helping to improve understanding of what administration is and how it can be more effective under the conditions and challenges of American life." Dr. Tead states at the outset that administration is "a fine art because it summarizes an imposing body of special talents on behalf of a collaterative creation which is integral to the conduct of civilized living today." This art is a reciprocal ongoing operation between organizations and the human individuals seeking their rightful, normal satisfactions who comprise those organizations.

Specifically calling attention to the fact that broader social standards must always be viewed as needing to be strengthened, Dr. Tead analyzes both the nature and acceptance of organization aims and the human needs or drives toward satisfaction which constitute "human nature in action." If more executives were to take to heart the author's italicized statement that "The individual's fullest use of his best talents is prompted under conditions which he has helped to determine and which he cherishes because he finds them helpful to his most satisfying self-expression and growth," there would certainly be more happiness in life, less turn-over of personnel in business, and greater social gain through happy productivity.

Sensitive to the human psychology and spirit, the author recognizes the importance of the aspects of self-responsibility, self-participation, and self-determination in political, social, and corporate situations as the end requirements of the realization of personality growth.

After an astute analysis of democratic society in action and of democratic difficulties, the author sets forth the substance of administration in all of its many aspects and gets on to the crux of the human side of administration as expressions of personal power and authority. Acknowledging that vital decisions rest upon the administration, Dr. Tead warns that they must not be "pulled out of a hat," but that the constructive use of personal power lies in "eliciting the willing aid of others in seeking common ends." Of authority he concludes that its best use is "the constructive synthesizing of judgments and opinions of informed associates to forward sound decisions."

Administration for collective cooperation for coordination and as an "educational function" are explored to the conclusion that the *Art of Administration* is an art in which public interest, corporate bodies, and the living human personalities that compose them are translated in such a way that Hocking's dictum that "the principle of the future state must be that every man shall be a whole man" is forwarded.

The "art of administration" may thus be termed an integrative art in which the executive, the leader, or the administrator as a person achieves his essential satisfactions also of power and authority with full awareness of the need for the personal satisfactions of every one of his human individual employees to derive *his* satisfactions in a situation in which all hold clearly in view the social and organizational aims and necessities to which all are loyal. This book should be taken to heart by all who find themselves in administrative and executive posts and especially by those whose semantics permit them to comprise the terms "executive" and "executioner." —H.W.C.

In *Concerning Science: A Study of the effect of science on human life and thought,* F. Sherwood Taylor (London: Macdonald, 1949, 141 pages) promises a most timely and provocative book:

"The outstanding characteristics of the world of today, are, on the one hand, its understanding and control of the material world; on the other hand, the obscurity and disorder manifest in human relationships. That the former is the result of natural science is obvious, and there is much to be said for the view that the latter is also a consequence of it.

"Is it not, then, a most extraordinary fact that only the smallest attention is given by those who educate us, whether in schools or universities, to the nature and functioning of this science, which has solved so many problems and is today posing so many more?

"The study of the effects of science on the individual and society is a necessity for every member of our modern scientific civilization, for, without it, he cannot understand the society he lives in . . . This book is intended to be an introduction to these questions and to advance some principles in the light of which science can be set in its true place in the world."

But upon reading into his discussion of science and scientific method, this reviewer cannot but express his regret at finding Mr. Taylor's account (note: not analysis) rather superficial; it is certainly not penetrating but done more in the manner of the traditional "popularizer" which only punctuates the obvious. Mr. Taylor's purpose, as stated above, certainly is welcome and commendable, and it is hoped that more serious and deliberate attention will be accorded such study by both educators and philosophers of science.—R. P. W.

Dr. Earl C. Kelley, the writer of *The Workshop Way of Learning* (Harper & Brothers, New York, 1951, 16 pages and index, $2.75), is a professor of secondary education at Wayne University. The volume is an account of ten years of development of a group-exchange process which runs weekly throughout the school year. About a hundred teachers participate in a break-away from traditional procedures. The following passage (pp. 85 - 86) may serve to represent the book in constant purpose and style:

"Grading systems everywhere are based on competition in the acquiring and giving back of subject matter. In the workshop we are more interested in the process of learning how to work with other people than in the specifics to be learned; we are most interested in the development of human relations, of techniques of meet-

ing and adjusting to others so that both will grow. This involves cooperation as a method of procedure.

"We are of course also interested in facts learned, as long as they are pertinent to the learner. We have evidence in our evaluative material that many facts are learned, and they are retained. We believe this is due to the relationship between the facts and the needs of the learner. Genuine work is one of our chief concerns, but the work cannot be pre-determined by us.

"If we were to announce to the workshop that the person who showed the most growth and was the most cooperative would receive the highest grade, we would have the absurd spectacle of people competing in cooperation. The staff would have many polished apples every week."

The group uses special persons for appropriate purposes: an expeditor of the group purposes, one or more resource persons, and so on. Here is an admirable account of the exploratory techniques which have been supplanting for years and in many schools of education, training courses where the latter are inappropriate. These admirable ventures constitute in themselves direct contributions to the true democratic process. We quote from page 38:

"The specific goal of the group should be arrived at through consensus. This means that it is talked through and modified until every member of the group can accept it as worthy. No group can succeed if there is a minority which cannot accept what the group is going to do. Such minorities will exist if the chairman resorts to voting as a means of gaining a decision. Parliamentary practice — the motion, the second, the vote — can ruin any group that is planning to work together, because it divides the group instead of bringing it together. Full discussion, understanding, and compromise can achieve goals which all can accept and on which all can spend themselves. This is consensus. . . . These written goals should be constantly in front of the group and regularly referred to; all planning should be done with these goals clearly in mind."

". . . In a culture like ours, in which science has become a dominant influence, it is natural that an understanding of the methods of science and its basic tools and generalizations should be recognized as essential elements in a liberal education. Even though not more than 10% of our students actually specialize in any scientific field, the great majority, whose careers will center in fields of business or government or the arts or teaching, must be able intelligently to evaluate the results of scientific investigation and how they are to be used and controlled. . . ."

—Prof. H. Plough in *Amherst Alumni News*

". . . what stimulates and excites the mind is not a description of the vast body of knowledge we have managed to accumulate (no matter how well organized nor how entertainingly presented), but rather an exposition of what we are trying to understand and how we are trying to do it. The most exciting part of any science is that of its frontiers; it would be a shame to leave the student unaware that such frontiers exist."

—Arnold W. Ravin, Department of Zoology, Columbia University in *Science,* Vol. 113, No. 2931, p. 249.

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